821 50MHZ OSCILLOSCOPE
OPERATION AND SERVICE MANUAL

BWD Precision Instruments Pty. Ltd.
(Incorporated In Victoria)
P.O. Box 298, Mulgrave North. 3170
5 Dunlop Road, Mulgrave Vic. 3170 Australia
Phone (03) 561 2888
Telex AA 35115

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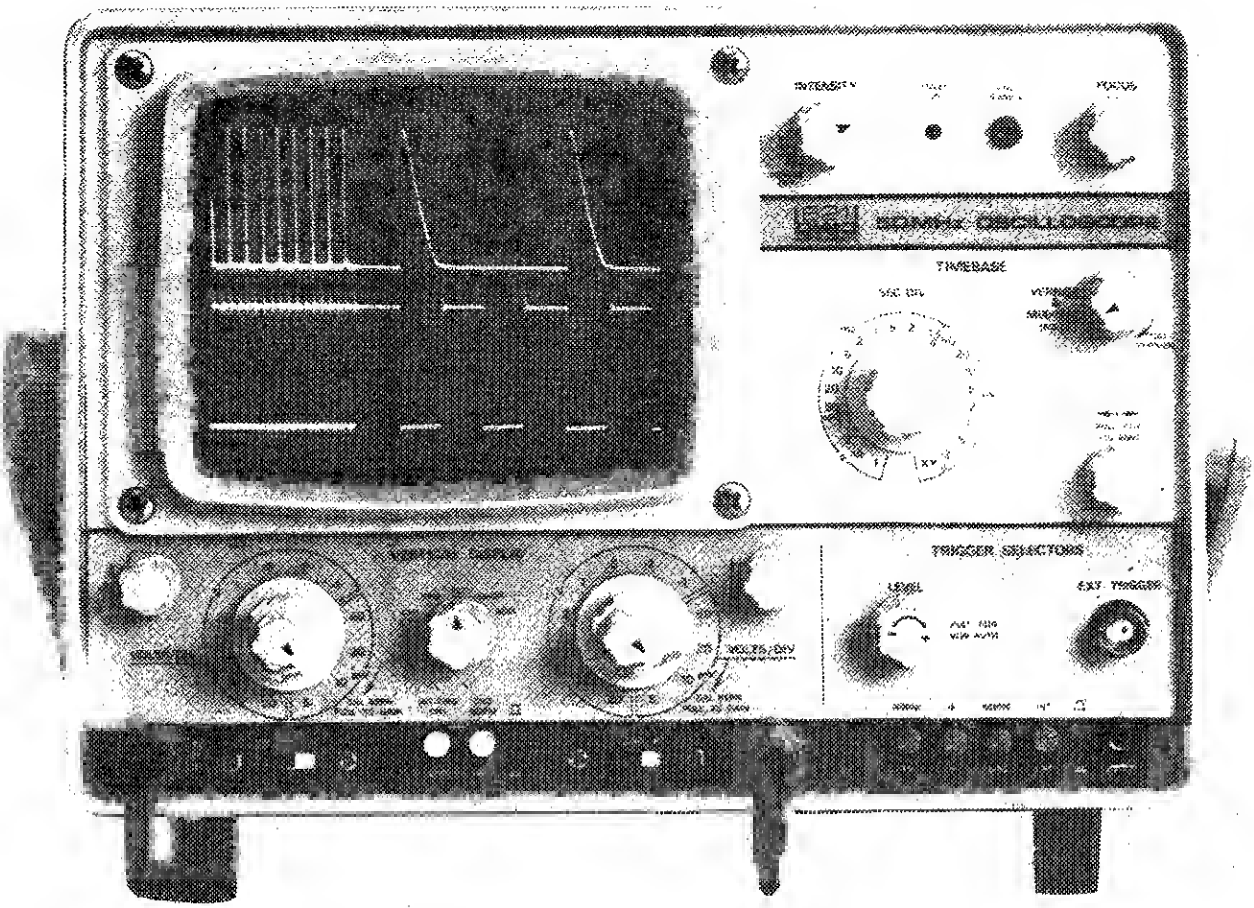


1.0 INTRODUCTION

The BWD 821 Oscilloscope is a remarkable instrument. It offers a 50MHz bandwidth at 5mV/div, 75MHz triggering, and incorporates a completely new MIX-MAG facility. This unique BWD feature enables both the normal x1 display and a x10 magnified display to be presented simultaneously at the turn of a knob. The magnified portion of the trace can extend from 0 to over 80% of the trace length.

If the normal x10 magnifier is used with the MIX-MAG, the trace can be magnified x100 to a maximum sweep speed of approx 10nsec/div.

These features, together with a 1mV/div max sensitivity, a wide range time base from 0.02µs/div down to 2.5 sec/div and an amplifier rise time of less than 7 nano seconds is suited to a large number of applications. It accurately displays fast digital pulses from TTL, CMOS or even ECL circuits making it suited for uprocessors, small home or business computers, video games and other digital equipments.

A video sync separator with automatic change over from frame to line lock makes servicing of video cassette recorders, colour TV's and all other video products a simple matter. The 1mV/div sensitivity vertical amplifiers can be switched to differential operation to view signals developed at any point in the circuit from the recording to the playback heads.

The same features that are ideal for video work are also excellent for all audio applications, including the new digital recording techniques. An identical XY facility with low phase shift to 200kHz is incorporated for specialist audio and telecommunication measurements. A useful feature of the video sync separator is that it will also demodulate a modulated carrier to enable the carrier envelope to be displayed.

To ensure the high performance characteristics will be maintained, the BWD 821 is built to high standards of manufacture and reliability. It closely conforms to IEC 348 recommendations and other relevant standards of safety in high quality electronic test equipment.

A wide range of accessories is available for the BWD 821 to further increase its usefulness. Details are listed at the end of Section 2.

SAFETY INFORMATION

1. At certain locations in this Handbook and on the instrument back or front panels will be found statements or symbols calling attention to a safety requirement or feature.

2. Symbols used are as follows:-

DANGER HIGH VOLTAGE

CIRCUIT GROUND

POWER LINE GROUND

CAUTION - Check Handbook to verify maximum input or output.

DANGER To alert of possible danger to either operator or equipment that may be present during the next Handbook procedure.

WARNING To alert operator that damage may occur to equipment under test if certain precuations as detailed, are not followed.

3. Do not use this instrument in an explosive atmosphere.

4. Do not remove the covers unless you are experienced in servicing this class of equipment, lethal voltages are present on several circuits.

5. **Instrument Power Source.** This instrument is designed for operation from a power source with its neutral at or near earth (ground) potential with a separate safety-earth conductor. It is not intended for operation from two phases of a multi-phase system, or across the legs of a single-phase three-wire system.

This instrument can be operated from either a 115 Volt or 230 Volt nominal line voltage source, 48 to 62Hz. This instrument may be damaged if operated with the line voltage connected to incorrect positions for the line voltage applied.

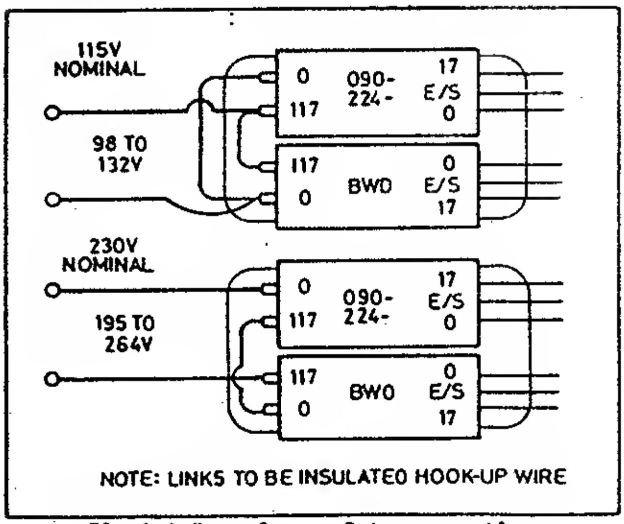


Fig 1-2 Transformer Interconnections

6. NOTE Colour-coding of the cord conductors is as follows:-

Line	Brown
Neutral	Blue
Safety Earth (Ground)	Green/Yellow Stripe

The power transformer is provided with primary tappings which may be changed by resoldering the links to suit the local power line voltages. The connections are as shown below. Instruments sold in Australia are connected for 195-264V operation. Export instruments have a label attached stating the operating range the transformer has been set to.

7. To avoid the possible hazard of fire or other internal damage, use only the fuse type and rating as specified on the rear panel and listed in the Handbook Parts List.

2.0 PERFORMANCE

2.1 VERTICAL AMPLIFIERS

Display Modes: CH1, CH2, Alt, Chopped, (approx 300kHz), Add.

Bandwidth: DC (or 4Hz AC coupled) to 50MHz -3db from 5mV to 20V. Referred to 6 div deflection from a 50ohm terminated source with vernier to Cal.

DC to 20MHz -3db at x5 (1mV & 2mV/div).

Rise Time: 7nsec over a 6 div deflection 5mV to 20V/div.
15nsec over a 6 div deflection 1 & 2mV/div.

Sensitivity: 1mV to 20V/div - 5mV to 20V direct and x5 multiplier for 1mV sensitivity. A vernier control with a range greater than 2.5:1 extends input to 50V/div.

Input R & C: 1Mohm +/-2% paralleled by approx 30pF.

Maximum Input Voltage: 400V (DC + peak AC). 800V (p-p at 1kHz or less).

Calibration Accuracy: 5mV to 20V/div +/-3%] +5°C to +40°C
1mV and 2mV/div +/-4%] add 2% 0° to +5° & +40°C to +50°C

Trace Inversion: CH2 may be inverted to provide a single channel differential facility in the Add mode.

CMRR: At least 20db from DC to 5MHz. Common mode signal < 8 div with one vernier adjusted for optimum rejection.

2.2 CH2 AS X AMPLIFIER IN XY MODE

Bandwidth: DC to 1.5MHz -3db.

Sensitivity: 1mV to 20V/cm.

Phase Shift: <2° from DC to 200kHz.

2.3 TIME BASE

Range: 0.2μsec to 1 sec/div, 21 steps in 1, 2, 5 sequence with 2.5:1 vernier which extends range to 2.5 sec/div.

Calibration:

Mag x1	Mag x10
+5°C to +40°C 0.2μsec to 1 sec/div +/-3%	+5°C to +40°C 50nsec to 0.1 sec +/-5% 20nsec over centre 8 div +/-5%
0°C to +5°C & 40°C to +50°C 0.2μsec to 0.2 sec/div +/-5% 0.5 & 1 sec/div +5% to -8%	0°C to +5°C & +40°C to +50°C 50nsec to 0.02 sec/div +/-7% 20nsec over centre 8 div +/-7% 0.05 & 0.1 sec/div +8% to -10%

2.4 MIX-MAG

Magnified Length:	Continuously variable from 0 to over 80% of trace length up to 2µsec/div sweep speed. Operation is available to 0.2 sec/div over a reduced length of the trace.
Calibration:	x1 as above for normal display. x10 as normal x10 display excluding 0.5 div after changeover, to a max of 100 nano sec/div sweep speed.
x100 Magnification:	The simultaneous use of x10 mag and MIX-MAG will provide x100 magnification. Calibration of the x100 section is better than 10% up to 100nsec/div. Max x100 magnified sweep speed is approx 10nsec/div.

2.5 TRIGGER

Source:	CH1, CH2, external or AC line frequency.
Video:	Frame or line selection with automatic changeover. Frame lock 0.1sec to 100µsec, line lock above 50µsec/div.
Slope:	Internal: + or - with level select over range of amplitude visible on screen External: + or - with level select over 4V p-p or 40V p-p with a 10:1 probe.
Sensitivity:	Internal: 0.4 div 15Hz to 10MHz increasing to 1 div at 5Hz & 50MHz External: 100mV p-p 15Hz to 10MHz 250mV p-p 1Hz to 50MHz
Ext. Input Impedance:	1Mohm +/-5% paralleled by 30pF approx.
Max. Input:	200V DC or DC plus peak AC to 1kHz.
Video Trigger:	2 div to over 8 div of composite waveform for frame or line lock.

2.6 GENERAL DETAILS

Timebase Gate Output:	+3V falling to 0V during sweep from 4.7kohm source.
Z Modulation:	DC coupled to 10MHz. Input impedance 10kohm. Max input +/-30V p-p. +4V will blank trace at normal intensity.

Calibrator:	Output 0.5V p-p, rectangular positive going with respect to ground, approx 1kHz. Less than 5µsec rise and fall time into 1Mohm and less than 40 pf. Accuracy 1% +15° to +35°C. 2% +5° to +40°C.
CRT:	Rectangular 8 x 10 div (1 div = 9.5mm).
	Internal graticule and mesh PDA operating at approx 6.0kV.
	Fitted with P31 phosphor and Blue filter.
Trace Rotation:	Rear panel preset enables trace to be aligned with graticule.

2.7 POWER REQUIREMENTS

AC: 95 to 132V and 190 to 264V by internal selection. 48 to 62Hz. 25 Watts max.

2.8 ENVIRONMENTAL

Specification is met unless otherwise stated between +5°C to +40°C at a relative humidity of less than 95% and from 0° to +50°C at a relative humidity of less than 50%.

Weight:	Instrument only:	7.8Kg
Shipping Weight:	Instrument only:	9.1Kg
Ordering Code:	Standard Model:	BWD 821

Instrument supplied complete with 2 x P32 1:1/10:1 probes, power cord and Handbook.

2.9 OPTIONAL ACCESSORIES

1.1 & 10.1 Duo Range Probe	P32	Protective Front Cover	SC53
100:1 1500V Probe	P37	Dust Cover	D30
Demodulator Probe	P34	Oscilloscope Trolley	T61-02
100 AMP DC-1kHz Current Probe	P82	Storage Pouch	SP30
Folding View Hood	H46	Cameras	

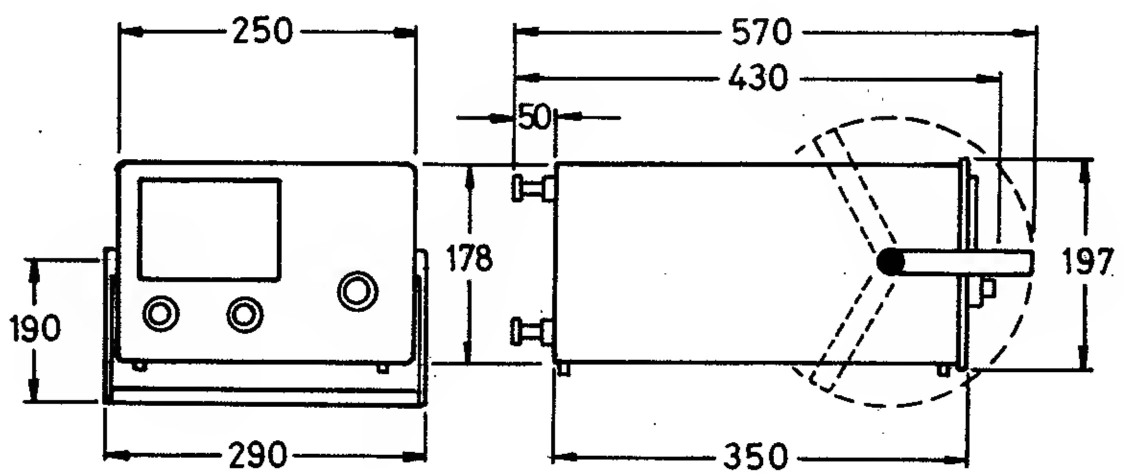


Fig 2-1 BWD B21 Dimensions in mm

3.1 FUNCTION OF CONTROLS

The following descriptions are to assist an operator to become familiarised with the location, operation and function of the **BWD 821** controls and connectors.

VERTICAL AMPLIFIERS SECTION (numbers refer to Fig 3.1)

1 and 2 CH1 and CH2 Volts/Div Control selects the vertical factor in a 1,2,5 sequence. (Vernier must be in the detent position for the indicated factor). Calibration accuracy is better than 3%.

3 Vernier Provides continuously variable deflection between the calibrated settings of the Volts/Div switches.

4 ↕ Positions the display vertically.

5 Inputs Connectors For application of signals to the vertical amplifiers. In the XY mode, signals applied to CH2 input provide the horizontal deflection.

6 DC-GND-AC Slide switch selects the input coupling to the vertical amplifiers. In the AC position signals are capacitively coupled to the vertical amplifier so the DC component of the signal is blocked. In the DC position, all components of the input signal are passed to the amplifiers. When switched to GND the input connectors are disconnected from the amplifiers and the attenuator input is grounded.

7 x5 Gain When the vernier controls are pulled out the channel gain is increased by x5, increasing the maximum sensitivity 1mV/div.

8 Vertical Display Rotary switch selects 5 modes of operation for the amplifier.

CH1	CH1 only displayed or Y in XY mode.
CH2	CH2 only displayed or X in XY mode.
ALT.	Dual trace display where the display is switched between channels at the end of each sweep during the return sweep.
CHOP.	Dual trace display where the display is switched between channels at the rate of approx 300kHz.
ADD.	Signals applied to CH1 and CH2 inputs are algebraically added and displayed as one trace on the CRT. With the CH2 INVERT switch engaged, the display is CH1 minus CH2, i.e. differential operation when both Volts/Div are at identical settings.

9 INT TRIGGER, CH1 or CH2 Push buttons to select source of internal trigger.

10 CH2 NORM-INV Push button. Trace is displayed normally when push button is out and inverted when in.

3.2 TIME BASE SECTION

11 Sec/Div Time base range switch controls the sweep time from 0.2µsec to 1sec/div in 21 steps. Turned fully clockwise, it switches off the time base and connects CH2 vertical amplifier to provide the X display for XY operation with a sensitivity from 1mV to 20V/div. When the vernier is at Cal the calibration is 3% over the entire range. Another function performed by the switch is to change over the video sync separator from frame selection to line selection at sweep speeds above 50usec/div.

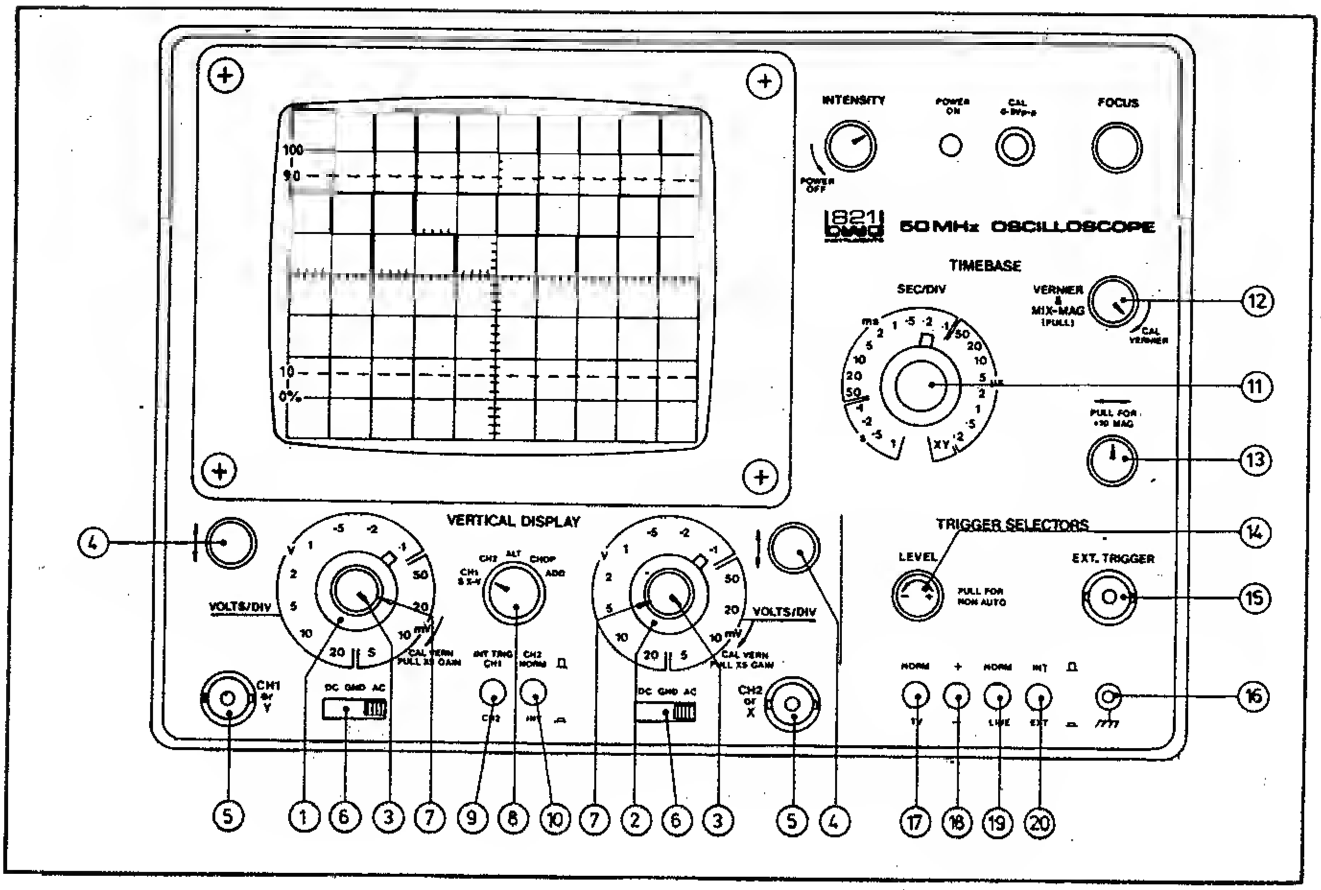


Fig 3-1 Front Panel Controls

12 Vernier Control When the control is pushed in, it operates as a vernier control, rotation counter clockwise reduces the time base speed by at least 2.5 times.

When the control is pulled out, the MIX-MAG facility is engaged. The time base is locked in its calibrated condition. Fully clockwise, the time base is displayed at x1 magnification. Rotation counter clockwise displays the right hand side of the trace magnified x10. Fully counter clockwise, enables at least 80% of the trace to be magnified at sweep speeds up to 2usec/div.

13 ◄—► & x10 MAG Control positions the trace horizontally on the screen. When the knob is pulled out, the sweep speed is increased by x10.

14 Level: Selects the precise point on the triggering waveform that initiates the time base. Selection is available over 8 div deflection; or up to 4V p-p external. When the level knob is pushed in, the time base will free run if a trigger signal is not present, or if the control is turned out of the range of the signal.

With the knob out, the automatic base line is eliminated and no trace is present in the absence of a trigger signal.

15 EXT TRIGGER input socket for application of signals to provide external trigger.

16 4mm socket for Ext connection to chassis.

3.3 PUSH BUTTON SWITCHES

17 NORM/TV out position is normal trigger; in position selects the video sync separator. When the time base is switched between 0.1 sec and 0.1msec/div, the sync separator supplies frame pulses to trigger the time base. From 50usec and above, the TV line will trigger the time base.

18 +/- Out position enables the positive or rising slope of the trigger waveform to initiate the time base. With the button in, the negative or falling slope triggers the time base.

19 AC Line Out is normal operation, in selects the line frequency powering the Oscilloscope to the trigger circuit to lock the trace. Phase of the trigger point is adjustable by the Level control and the +/- switch.

20 INT/EXT Out position connects the internal trigger signals as selected by the trigger source button in the vertical amplifier section. The in position, selects signals applied via the External trigger BNC socket.

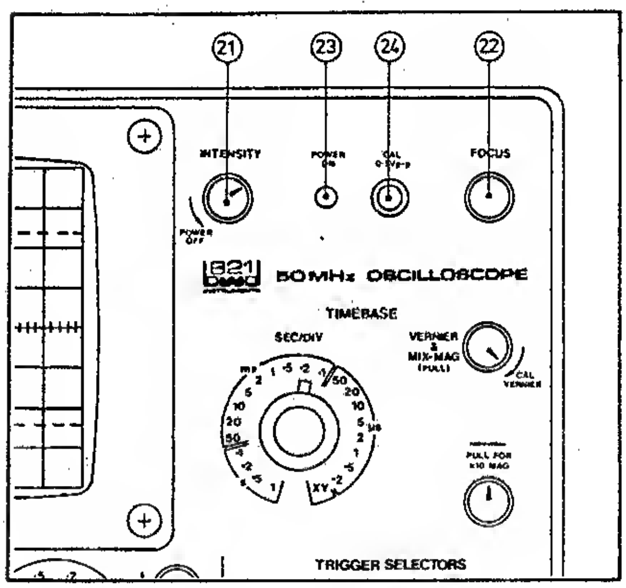


Fig 3-2 CRT Controls

3.4 CRT CONTROLS

21 Intensity-ON/OFF fully counter-clock switches off the Oscilloscope.

When turned clockwise, the Oscilloscope is switched on and rotation clockwise increases the trace intensity.

22 Focus Adjusts the CRT focus at any setting of the intensity control. Adjustment is made in conjunction with the rear panel astigmatism preset control to obtain the optimum trace sharpness.

3.5 GENERAL FEATURES

23 LED Power Indicator Illuminates when the Intensity control is turned on.

24 CAL 0.5V p-p Approximately 1kHz rectangular positive going waveform of 0.5V p-p amplitude. Rise time is less than 5usec into a BWD P32 Probe.

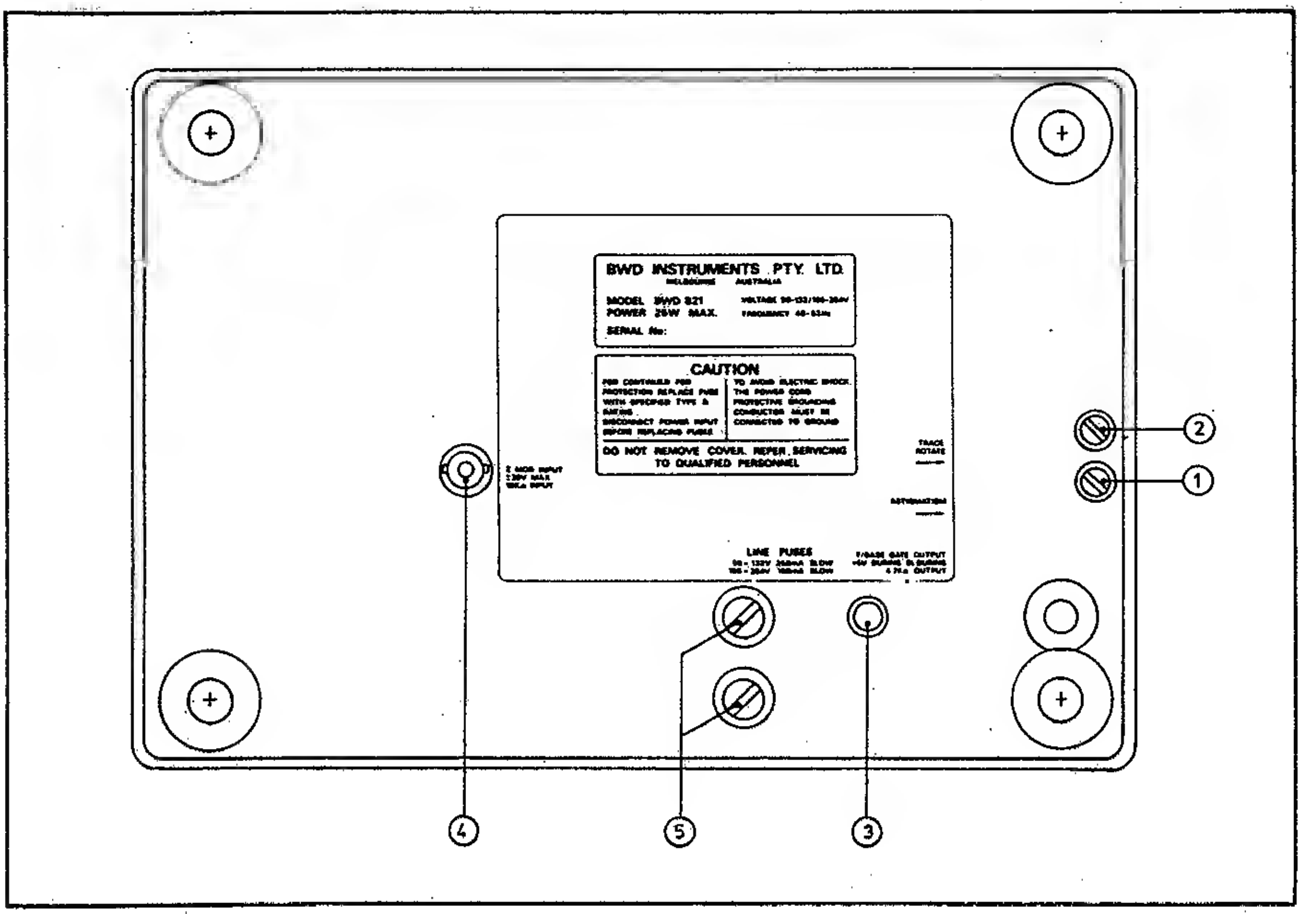


Fig 3-3 Rear Panel Facilities

3.6 REAR PANEL FACILITIES

1 Astigmatism Preset used in conjunction with the front panel focus control to adjust the trace sharpness. Will rarely need adjustment once correctly set.

2 Trace Rotate Preset control enables the CRT trace to be aligned with the internal graticule.

3 T.B. Gate Time base blanking waveform. 0V during sweep. +3V during blanking, 4k7 source impedance.

4 Z MOD Input socket for intensity modulating the CRT. Maximum input is +/-30V and input impedance is 20kohm. Modulation requires a positive input of +4V to blank trace at normal intensity.

5 AC Line Fuses One fuse is fitted in each line. Fuse size and value is shown in Parts List and must be adhered to for maximum instrument safety.

FIRST TIME OPERATION

4.1 One of the major features of the **BWD 821** Oscilloscope is that normal operation is obtained when all controls are in their normal position, i.e. when all push buttons are OUT and all controls are pushed in. A quick scan over the panel therefore immediately indicates any variations from normal and assists in quick familiarisation of the instrument's operation.

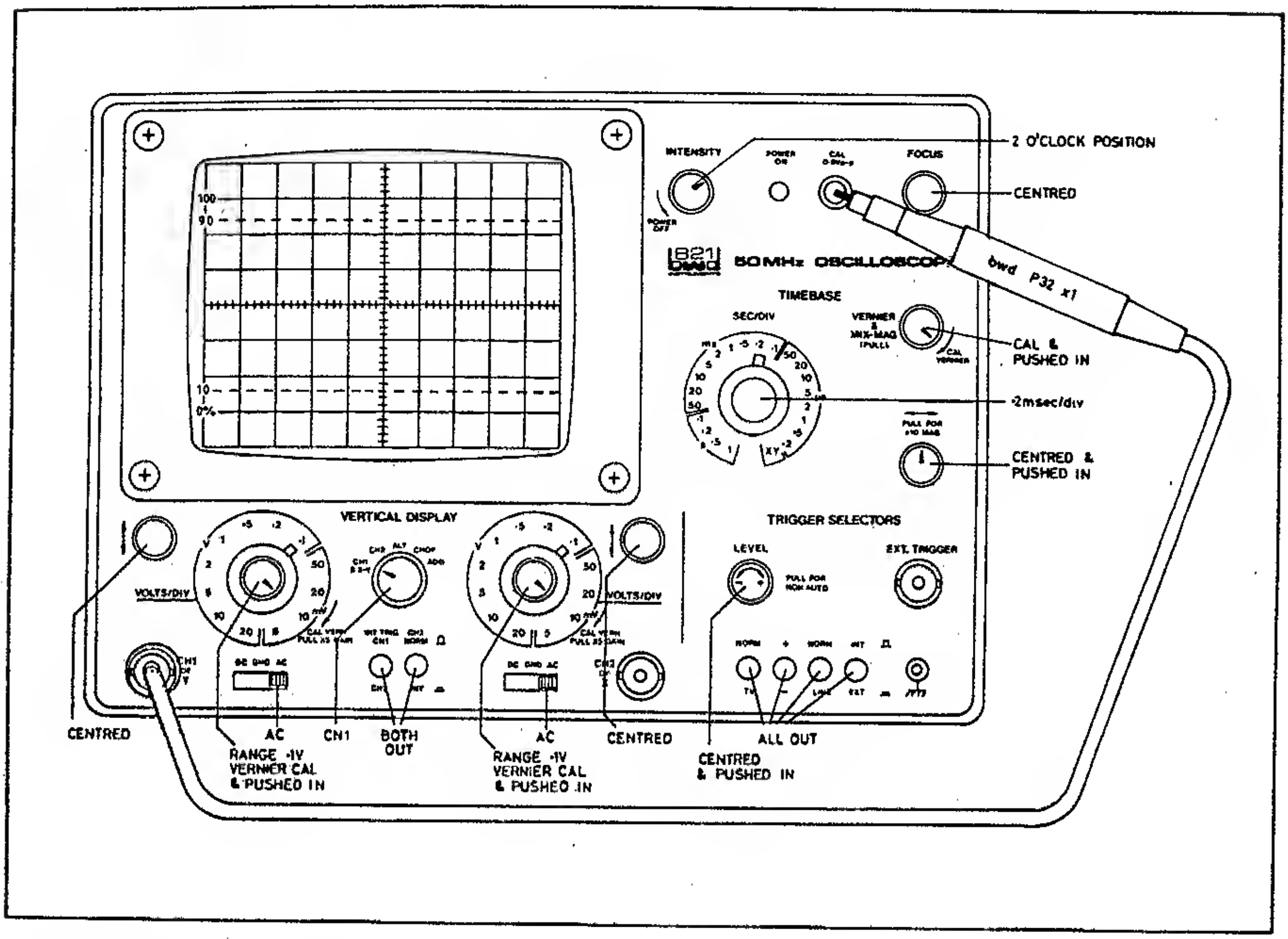


Fig 4-1 First Time Set Up

VERTICAL AMPLIFIERS

4.2 SINGLE TRACE OPERATION

For first time operation, if you are unfamiliar with this type of Oscilloscope, set the controls as above and follow the steps outlined until each feature is understood.

4.3 Apply power to the Oscilloscope, switch on and turn the Intensity Control to approx 2 o'clock position. Within 15 seconds a trace will appear. Adjust intensity focus and position to set trace centrally across screen. If trace is not aligned with the graticule, adjust the Trace Rotation preset on the rear panel to align it.

Now connect a BWD P32 Probe to CH1 input and set it to 1:1. Touch the Probe tip to the 0.5V CAL waveform output socket.

A rectangular wave will be displayed 5 div high and one waveform per 5 divisions horizontally. Slide the CH1 input switch to DC, the trace will rise and the bottom of the waveform will now correspond with the CRT centreline indicating the input signal is a waveform positive going with respect to ground. Slide the input switch to GND, the square wave will be removed and replaced by a bright reference base line as the Auto time base operates. The GND switch disconnects the input signal in this condition, but grounds the amplifier. Slide the switch back to DC and the waveform will again be standing on the centreline.

4.4 DUAL TRACE OPERATION

Set CH2 amplifier as for CH1, then turn the VERTICAL DISPLAY to CH2, then press the INT TRIG button to select CH2. Take a parallel signal from the calibrator output, (or a similar waveform) to CH2 input leaving CH1 signal connected.

ALT

Reduce attenuator settings on both amplifiers to 0.2V/div then switch Vertical Display to ALT. Two traces will appear which can be positioned above and below CRT centreline with their respective controls.

With the traces positioned above each other, switch the time base range switch to slower sweep speeds and observe how flicker between the traces increases, until at 10msec/div the switching between the traces is readily visible. This is the useful lower limit of the ALTernate switching mode. Now increase the time base speed, the traces will remain locked right through to 0.2µsec/div.

CHOP

Return time base range to 10msec/div again and switch the Vertical Display to CHOP. Trace flicker immediately stops. When the time base frequency is reduced, the two traces appear simultaneously down to the lowest sweep frequency.

Increase time base speed and note that at speeds above 50usec/div the waveforms will start to show the individual chopping sections indicating the useful upper limit of CHOP displays.

As has been shown, a wide overlap exists where both forms of dual trace display can be used satisfactorily.

ADD

Apply a 1V p-p 1kHz sine wave to CH1 and CH2 inputs. Set the time base to 0.5msec/div and both attenuators to 0.5V/div so that the waveform on each trace is 2 div high. Turn the Vertical Display switch to ADD.

A single trace will appear with a 4 div display, i.e. the two traces have been **added** together. Now press CH2 NORM/INV button; the waveform will disappear leaving only a line. This is the **difference** between the two signals or the result when one is subtracted from the other. Applications for this form of measurement are described later. Return Vertical Display switch to CH1 and the NORM/INV switch to NORM.

4.5 TIME BASE

Increase sine wave input to CH1 to present a 6 div high display and select CH1 trigger.

4.6 TRIGGER LEVEL

With the Level knob pushed in, turn the control and observe that the trigger point moves up or down the waveform. When it reaches the top or bottom of the waveform the trace blanks out for a fraction of a second when trigger is lost, then the trace free runs in the Auto condition until the level control is readjusted to select a trigger signal. Now push in the +/- button to select -ve trigger. The waveform will now trigger on a -ve going slope. Clockwise rotation of the level control will increase the trigger point level towards the positive point of the waveform, anti-clock rotation towards the negative point.

Revert to +ve trigger selection, then pull out the Level knob to normal or non-Auto operation. When the level control is now turned, the trace disappears when the trigger point extends past the waveform limits.

The 821 trigger level control has a variable sensitivity providing a fine control in the centre of its range, enabling signals below 4mm amplitude to be reliably locked at frequencies up to 10MHz.

4.7 T.B. VERNIER

Turn Vernier anticlockwise - observe the number of waveforms on the CRT increases by at least x2.5 times when fully counter clockwise. Return control to CAL.

4.8 MIX-MAG

Increase input signal to 2kHz, but reduce time base speed to 5msec/div. Pull out T.B. Vernier knob, trace will remain in Calibrated condition. Rotate Vernier knob counter clockwise; the right hand side of the display will appear magnified x10. If the control is turned fully counter clockwise, over 8 divisions of the trace will be magnified.

If the horizontal position control is also pulled out to x10 mag, the display will be magnified x100 with an accuracy typically better than 5%.

Always remember to switch the Vernier control back to CAL when switching MIX-MAG out of operation.

4.9 MAGNIFICATION

Adjust input frequency to produce one sine wave per div and locate the peak of each waveform on a vertical graticule line. Pull out the horizontal position control for x10 magnification.

The trace will expand either side of the centre and any portion of it can be viewed by rotating the position control. Return to x1 and recentre trace horizontally.

4.10 HORIZONTAL AMPLIFIER

Identical XY

Parallel a 2kHz input sine wave to CH1 and CH2, adjust both for a 6 div display, turn the time base range switch to XY and pull out the x10 mag knob. CH1 will now present the vertical display and CH2 the horizontal. To position the display horizontally use the horizontal position control.

Vernier control between attenuator steps is available for both the vertical and horizontal axis. For zero phase shift betwen XY inputs at low frequencies it is essential to use DC coupling on both channels.

4.11 MODULATION

Reset all push buttons to 'out', connect 5V p-p sine wave to CH1, switch attenuator to 1V/div. Set Vertical Display to ALT. Position displays one above the other. Now parallel the 5V signal into rear panel Z Mod socket. The tops of each displayed sine wave will diminish in intensity and the CH2 trace will be broken into a series of light and dark sections.

NOTE: A positive going signal decreases the trace brightness. A negative signal increases intensity. As the input impedance is only 10kohm the signal source should be a low impedance to provide the sensitivity specified. Maximum input must be limited to +/-30V.

APPLICATIONS

5.1 Once the basic operation of the instrument is understood, it can be applied to waveform measurement. As the BWD P32 Probes supplied with the Oscilloscope are likely to be widely used to conduct the signal from the product under observation to the Oscilloscope amplifiers, it is essential that they be correctly adjusted before making connection with them.

5.2 PROBE COMPENSATION

The BWD P32 Probe has both an x1 and x10 divider ratio. No compensation is provided in the x1 position as no signal division takes place. Incorrect adjustment in the x10 position can cause measurement errors at all frequencies above 100Hz. Check the probe regularly to ensure it remains correctly adjusted.

Adjust probe as follows:-

1. Connect P32 probes to CH1 & CH2 inputs. Select x10 on probe bodies.

2. Set both VOLTS/DIV switches to 10mV and DC-GND-AC switches to DC.

Set VERTICAL DISPLAY to CH1 and insert tip of CH1 probe into PROBE ADJUST socket.

4. Set the time base to display 4 or 5 cycles of the signal and center the display.

5. Adjust the probe compensation if necessary, to produce a flat top waveform, using the small screwdriver supplied with the probe.

6. Repeat process for CH2 probe. For further details of the BWD P32 probe characteristics, refer to the leaflet supplied with the probe.

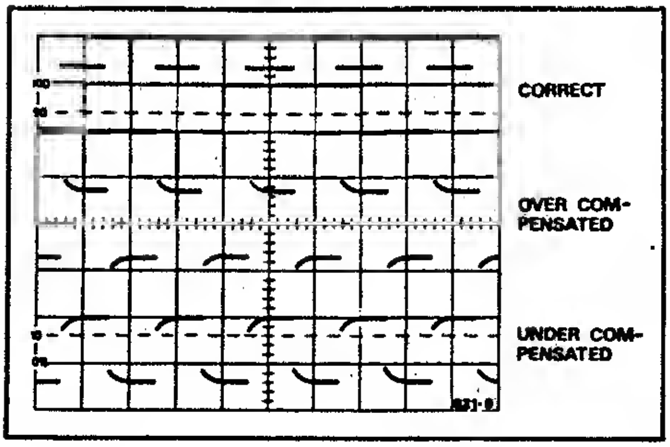


Fig 5-1

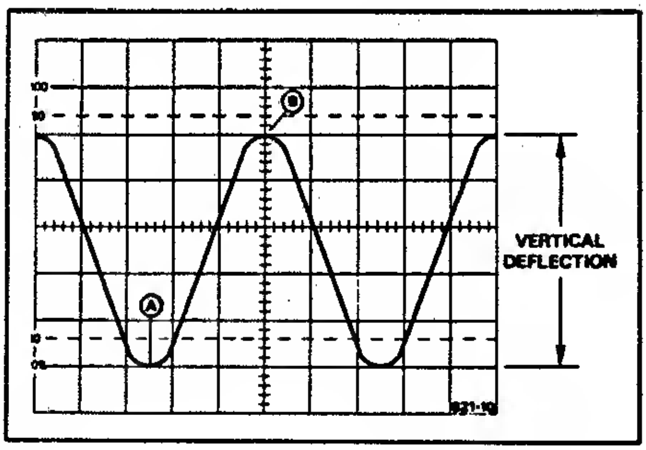


Fig 5-2

5.3 VOLTAGE MEASUREMENT, AC

To measure the peak to peak voltage of the waveform shown in Fig.5-2 proceed as follows:-

a. Connect the signal to be measured to the CH1 input connector.

b. Set the VERTICAL DISPLAY to CH1, and the DC-GND-AC to AC. Then adjust the VOLTS/DIV switch to present the largest waveform within the graticule limits and the time base and trigger for a suitable display. Ensure the VOLTS/DIV VERNIER controls are fully clockwise in the CAL position.

c. Use the vertical and horizontal position controls to align the bottom edge of the waveforms with a horizontal graticule line and the top of one of the waveforms in line with the vertical graticule centreline.

d. Measure the vertical distance between points A & B and multiply by the setting of the VOLTS/DIV control.

If a probe is used, multiply the value obtained by the attenuation ratio, i.e. Volts peak to peak = Vertical deflection x VOLTS/DIV x probe attenuation ratio.

NOTE: If the amplitude measurement is critical, or if the trace is thick (as a result of hum or noise on the signal), a more accurate value can be obtained by measuring from the top of a peak to the top of a valley. This will eminate trace thickness from the measurement.

Engage the 20MHz Bandwidth Limit switch to sharpen the trace by removing very high frequency noise, if frequency is below 5MHz.

e. **Example**

The Vertical deflection of the waveform in Fig.5-2 is 5 div. If the VOLTS/DIV is set to 0.5V and the probe is x10, then the result is:-

5 (div) x 0.5 (V/DIV) x10 = 25V p-p

5.4 VOLTAGE MEASUREMENT, rms

a. If the waveform measured in Fig.5-2 is sinusoidal, its r.m.s. value can easily be calculated by the following formula.

$$\text{Volts rms} = \frac{\text{Volts p-p}}{2\sqrt{2}}$$

From the previous example:-

$$\text{Volts rms} = \frac{25}{2\sqrt{2}} = \frac{25}{2.818} = 8.84\text{Vrms}$$

5.5 VOLTAGE MEASUREMENT, DC

To measure DC waveforms shown in Fig.5-3, proceed as follows:-

a. Connect the signal to be measured to the CH1 input connector.

b. Set the VERTICAL DISPLAY to ALT and the DC-GND-AC to DC. Then adjust the VOLTS/DIV switch to present the largest waveform within the graticule limits.

Time base and trigger should be adjusted for a suitable display. Ensure the VOLTS/DIV VERNIER is in the CAL position.

c. Set the DC-GND-AC switch to GND to establish how the waveform is related to ground. Move the CH1 trace until it corresponds with the nearest graticule line. Now superimpose CH2 trace on CH1 to provide a reminder of the ground reference level.

d. Return CH1 DC-GND-AC switch to DC. Do not move either vertical position control. However, if the waveform is now partly off the screen, reduce the signal amplitude by the VOLTS/DIV switch. This will not affect the ground reference levels already determined.

e. Use the horizontal position control to bring the portion of the waveform to be measured to the centre graticule line.

f. Measure the vertical distance from the ground reference graticule line to the point to be measured.

g. Multiply the Vertical Deflection above or below the ground reference as required by the VOLTS/DIV setting and the probe attenuation ratio.

Example

The +ve Vertical deflection of the waveform in Fig.5-3 is 3.8 divisions. If the VOLTS/DIV is set to 2 and the probe is x1, then the result is:-

+3.8 × 2 × 1 = +7.6V

The negative deflection is 2 div, therefore the voltage deflection below ground is:-

-2 × 2 × 1 = -4V

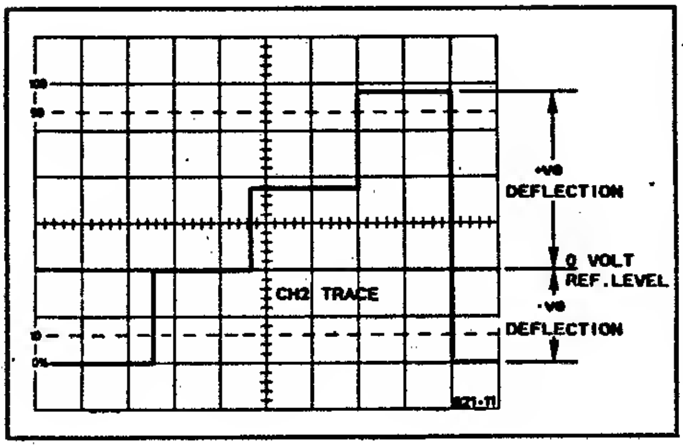


Fig 5-3

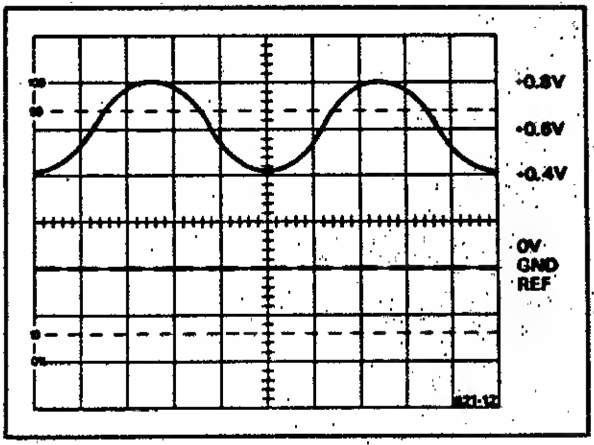


Fig 5-4

5.6 VOLTAGE MEASUREMENT, DC + AC p-p

To measure both AC and DC components of a signal, move the input switch to GND. If the waveform is positive to ground, set the trace on the bottom graticule line. Return the switch to DC and adjust the VOLTS/DIV switch for the maximum amplitude display. Measure the AC p-p voltage as described under 5.3 and the DC component between the required levels as described under 5.5.

Example

With the attenuator set to 0.2 Volts/Div and the input probe switched to X1 the:-

AC component = 0.4V p-p and the
DC component (to centre of AC waveform) = 0.6V

Note: When the DC component is much greater than the AC component, the AC may be too small to measure. In this case, measure the AC and DC components separately.

5.7 VOLTAGE MEASUREMENT, ELIMINATION OF COMMON MODE SIGNALS

a. By combining the use of the VERTICAL DISPLAY ADD with the CH2 NORM/INV facilities undesired signals on which the desired signal is riding can be removed.

b. Apply the signal containing both the desired and undesired signals to CH1 input connector.

c. Apply the undesired signal to CH2 input connector.

d. Set the VERTICAL DISPLAY to ADD and the NORM/INV switch to INV.

e. Set both VOLTS/DIV switches to the same sensitivity. The display should now show the desired signal. If some residual is still present, use the CH2 VOLTS/DIV switch and VERNIER control to reduce it to the lowest level.

f. Waveform measurement of the required signal can be made as described in para 5.3.

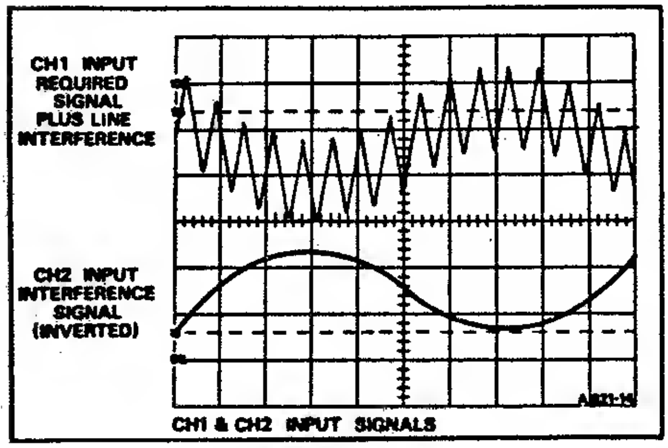


Fig 5-5A

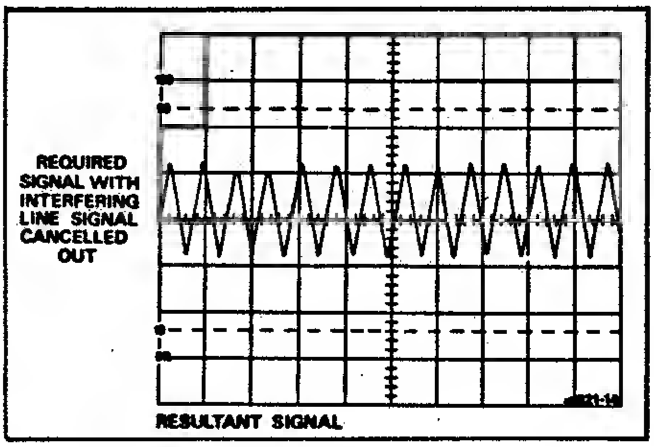


Fig 5-5B

5.8 CURRENT MEASUREMENT, AC & DC

Although a voltage signal is the only phenomena that can be observed on an oscilloscope directly, it is possible to convert other phenomena into voltage and so obtain another measurement.

Current can be measured in two ways:-

By measuring the voltage developed across a resistor which is converted to current using Ohms law, or:-

By using a current probe, such as the BWD P82.

1. Current Through a Known Resistance

If one end of the resistor is at ground potential, connect a P32 probe to the active end and measure the AC and/or DC voltage developed across it, as described in para's 5.3 and 5.5.

a. Example

If the DC voltage across a 10ohm resistor is measured as 0.23V then the current flowing is found from $I = \frac{E}{R}$

$$1 = \frac{0.23}{10} \text{ Amps or } \frac{0.23 \times 1000}{10} \text{ mA} = 23\text{ma}$$

AC p-p current is measured the same way and converted to rms values if sinusoidal as in para 5.4.

b. If the circuit resistor is not grounded at one end, the voltage drop across it can be measured differentially as described in para 5.7, by connecting CH1 probe to one end, CH2 to the other and then setting both probes to x1 or x10 as required, **both** CH1 & CH2 attenuators to the same VOLTS/DIV to bring the trace on the screen and **both** DC-GND-AC switches to AC or DC as required and CH2 NORM/INV switch to INV.

c. If DC measurements are made, ensure the DC to ground voltage present on the component does not exceed x8 the attenuator setting or the measurement will be accurate.

d. Differential measurements across the component are made in exactly the same way as normal AC or DC measurements described under 5.3 & 5.5, i.e.:-

vertical deflection × Volts/Div × Probe Attenuation Factor

and then converted to current as described under 5.8a.

2. BWD P82 Current Probe

In high current circuits where a wire is available to clamp a probe around a P82 probe enables current waveforms from DC to over 1kHz and at levels to 100 Amps to be measured. The probe cable is plugged into one vertical channel, the attenuator set to 1V/div and the resulting waveform is converted to current by the following formula:-

I amps = vertical deflection x10 or x100 (depending on range selected on P82 probe)

Example: If vertical deflection is 6 div and P82 range is x10:-

I = 6 x 10 = 60 Amps

5.9 TIME MEASUREMENT

a. To measure the time of each cycle of the waveform shown in Fig 5-6 set the oscilloscope up as follows.

b. Connect the signal to be measured to CH1 input connector. Set the VERTICAL DISPLAY to CH1.

c. Adjust the trace vertically to set the part of the waveform to be used as the reference to cross the graticule horizontal centreline.

d. Adjust the time base to expand the waveform as wide as possible to obtain the most accurate measurement. Ensure the SEC/DIV VERNIER control is in CAL.

e. Measure the Horizontal deflection where the waveform cuts the centre graticule line. Multiply this by the TIME/DIV setting and by x10 Mag if this control is switched into operation.

f. **Example**

Time = Horiz Defl x SEC/DIV x MAG

For the waveform shown in Fig 5-6 the Horz Defl = 6.1 div, assume the SEC/DIV is 2msec and magnifier to x1

Time = 6.1 x 2 x 1 = 12.2msec

5.10 FREQUENCY MEASUREMENT

a. The frequency of a repetitive waveform is made by measuring the period of one cycle of the waveform and taking the reciprocal of it.

b. **Example**

Using the waveform in Fig 5-6 and the example on 5.9f. which determined a period of 12.2msec

$$\text{Frequency} = \frac{1}{\text{period}} = \frac{1\times10^3}{12.2} = 82\text{Hz}$$

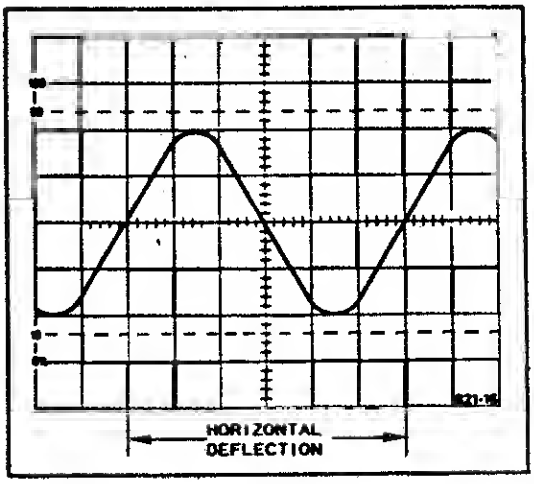


Fig 5-6

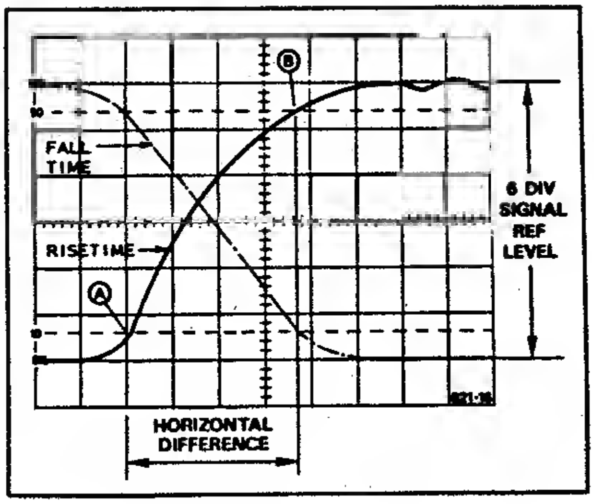


Fig 5-7

5.11 RISE & FALL TIME MEASUREMENT

a. Rise or fall time measurement follow the same procedure as Time measurements, but use the 0, 10, 90 and 100% calibration lines on the graticule. Use the following procedure to make the measurement.

b. Apply the signal to CH1 input and set the VERTICAL DISPLAY to CH1.

Use the VOLTS/DIV and the VERNIER control to set the waveform peak to peak height to correspond to the 0 and 100% graticule lines.

Ensure the A SEC/DIV VERNIER is in the CAL position.

c. Move with the horizontal position control, the point on the waveform corresponding to the 10% line until it also corresponds with vertical graticule line.

Measure the horizontal difference between the 10% and 90% points on the waveform.

d. Multiply this by the SEC/DIV and by the horizontal magnification.

Example

e. The waveform in Fig 5-7 has a Horizontal difference of 3.7 div. If the SEC/DIV was 4µsec and magnification was x1

Rise Time = Horiz difference x SEC/DIV x Mag.
Rise Time = 3.7 x 4µ x 1 = 14.8µs

f. Fall time is measured in the same manner, excepting the 90% fall point is aligned with a vertical graticule mark as shown by the dotted line in Fig 5-7.

5.12 TIME DIFFERENCE MEASUREMENT

a. Time difference between two pulses on waveforms that are synchronised to each other, but one is delayed in time.

b. Apply the two signals to CH1 & 2. Set the VERTICAL DISPLAY to ALT or CHOP depending on the pulse repetition rate.

c. Set the VOLTS/DIV switches for a suitable display amplitude and the SEC/DIV to separate the two pulses to the greatest degree possible within the screen limits.

d. Measure the horizontal difference between the two signals, multiply by SEC/DIV setting and horizontal magnification.

e. **Example**

The waveform in Fig 5-8 shows a horizontal difference of 3.5 div and assuming the SEC/DIV range is 0.5μsec and the magnification is x1, the time between the pulses is:-

Time = Horizontal difference x SEC/DIV x magnification
Time = 3.5 x 0.5μ x 1 = 1.75μsec

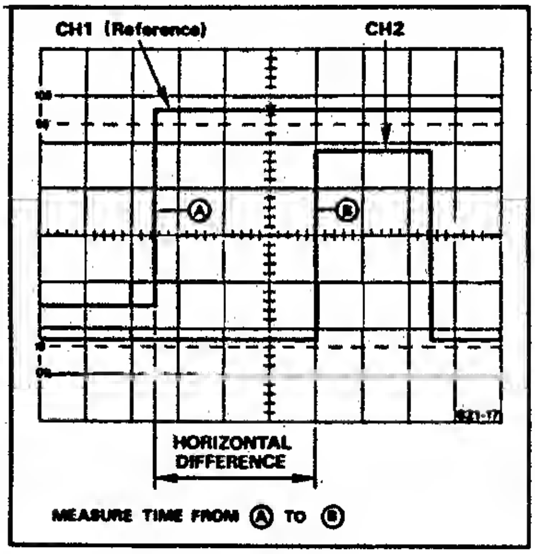


Fig 5-8

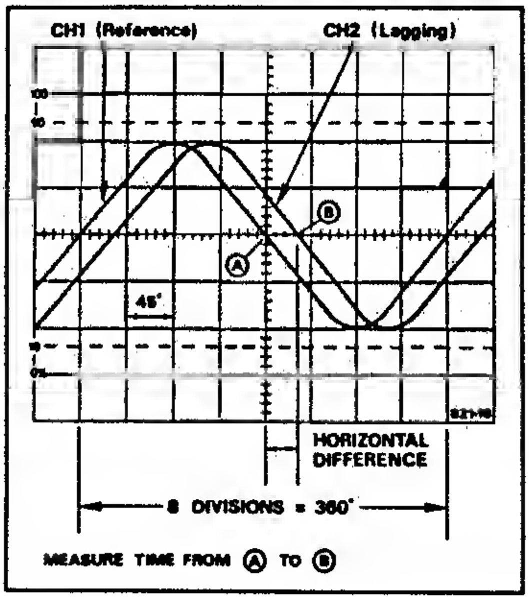


Fig 5-9

5.13 PHASE MEASUREMENT

a. Two methods of measuring phase are described. The first is for relatively large phase angles over the oscilloscope's entire vertical bandwidth. The second method is for precise measurements of small phase angles over a DC to 300kHz frequency band.

5.14 PHASE DIFFERENCE MEASUREMENT

a. Apply the two signals to CH1 and CH2 inputs. Select ALT or CHOP VERTICAL DISPLAY as necessary for the waveform frequency.

c. Adjust the VOLTS/DIV switches for the largest display that can be accommodated, making each signal approx equal in amplitude. Select the reference waveform as the trigger channel and adjust the trigger LEVEL control until the reference waveform is triggered at a point just below the graticule centreline.

NOTE: If one waveform is inverted to the other, press the CH2 INV button.

c. With the SEC/DIV switch and its VERNIER control, adjust the display so that one cycle of the signal occupies 9 divisions of horizontal display.

One division now equals 40° and each sub-division is 8°.

d. Ensure that each waveform is centred vertically on the graticule, then measure the horizontal distance between the rising portion of the waveforms.

e. **Example**

The waveforms in Fig 5-9 have a difference of 0.8 divisions, therefore the Phase Difference = Horizontal difference x 40°

Phase angle = $0.8 \times 40 = 32^{\circ}$

f. To obtain a higher resolution if the phase angle is less than 8°, the display can be magnified x10 after setting up as in 5.14c. Each division is now expanded to 4° and each sub-division to 0.8°.

Fig 5-10 below shows the result when the waveform is positioned centrally on the CRT.

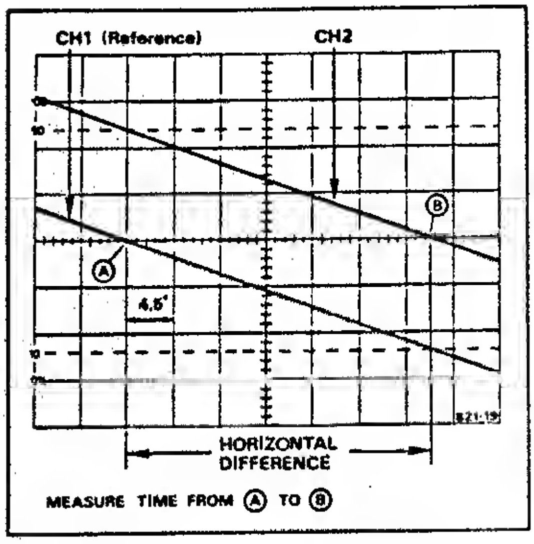
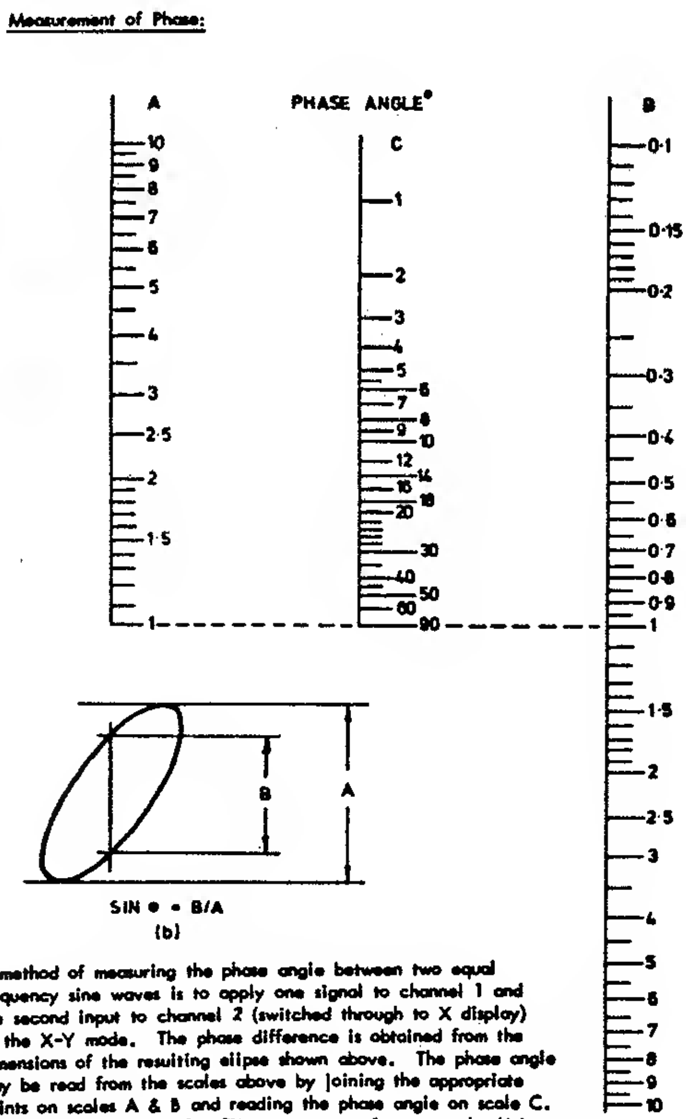


Fig 5-10



A method of measuring the phase angle between two equal frequency sine waves is to apply one signal to channel 1 and the second input to channel 2 (switched through to X display) in the X-Y mode. The phase difference is obtained from the dimensions of the resulting ellipse shown above. The phase angle may be read from the scales above by joining the appropriate points on scales A & B and reading the phase angle on scale C. For a phase accuracy of > 2% measurement frequency should be below 100kHz.

Fig 5-11

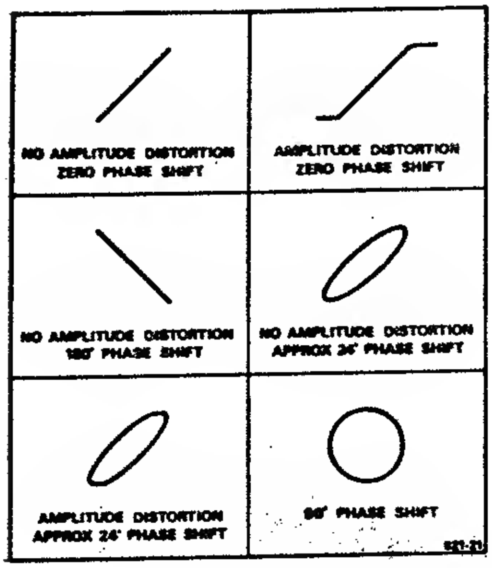


Fig 5-12

5.15 X-Y PHASE MEASUREMENT

a. Connect the reference sine wave to CH1 input and the signal to be checked to CH2.

b. Adjust the levels for 6 div amplitude with the VOLTS/DIV switches and VERNIER controls.

If low frequencies are to be checked, set the DC-GND-AC switches to DC. If this is not possible, due to an offset voltage on one input, set both switches to AC. However, phase shift may now occur below 10kHz, due to possible variation in the input coupling capacitors.

c. Switch VERTICAL DISPLAY to CH1 & X-Y and the HORIZ DISPLAY to X-Y. Also switch the TRIGGER SELECTOR to EXT and the LEVEL control to NORM.

d. If no phase shift is present, a straight diagonal line will appear. If phase shift is present, the line will widen out to an elipse.

e. Phase shift between the two waveforms can be obtained from the chart in Fig 5-11. Max usable frequency range for this method of measurement is DC to 300kHz.

f. Typical displays are shown in Fig 5-12 including the effect of waveform distortion.

5.16 VIDEO (TV) DISPLAYS

The time base and trigger facilities are extremely versatile for video measurements. Displays from a single frame to selected lines from alternate frames may be presented in the dual trace display.

a. Apply the video waveform to CH1 and adjust the attenuator for a 3 to 4 div display. Press the TV button and if the sync signal is positive going, select the + trigger polarity button. If sync is negative going, select - polarity.

b. With the A VOLTS/DIV to 2msec adjust the Level control for a stable lock of the frame video signal.

If the time base is turned towards 50µsec the trace will remain locked, but will change over from displaying the frame signal to the line signal.

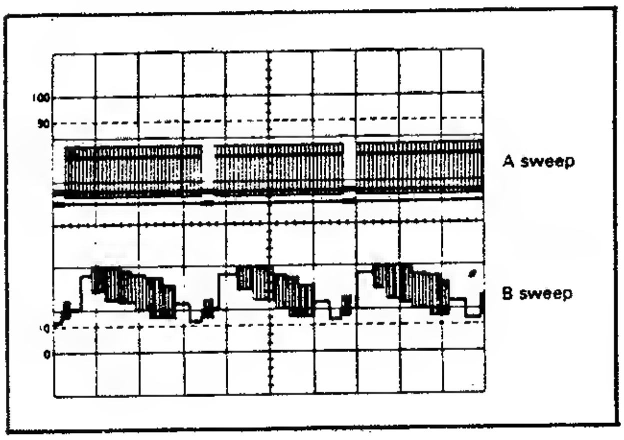


Fig.5-13

To look at lines carrying Tele Text information increase the time base speed to 100µSec/div. Now pull out the time base vernier knob to engage MIX-MAX. Adjust the control to magnify the required lines.

Alternate frames can be displayed in the ALT dual trace mode by increasing the time base speed to 1msec/div or faster to display only the first part of the frame signal. It will then automatically display alternate frame signals and when lines are selected in the MIX-MAG mode they will be from alternate frames.

5.17 EXTENDING THE USABLE CALIBRATED AMPLIFIER RANGE

Calibration accuracy of any oscilloscope is only valid to approx. half the bandwidth limit as this is where the response starts to fall to its -3db level. To extend the accuracy of the BWD 821 to beyond the half bandwidth point the following amplifier response chart may be used to interpolate the real amplitude of the displayed waveform.

Note: Signal amplitude should be kept below the 6 div response line for greatest accuracy.

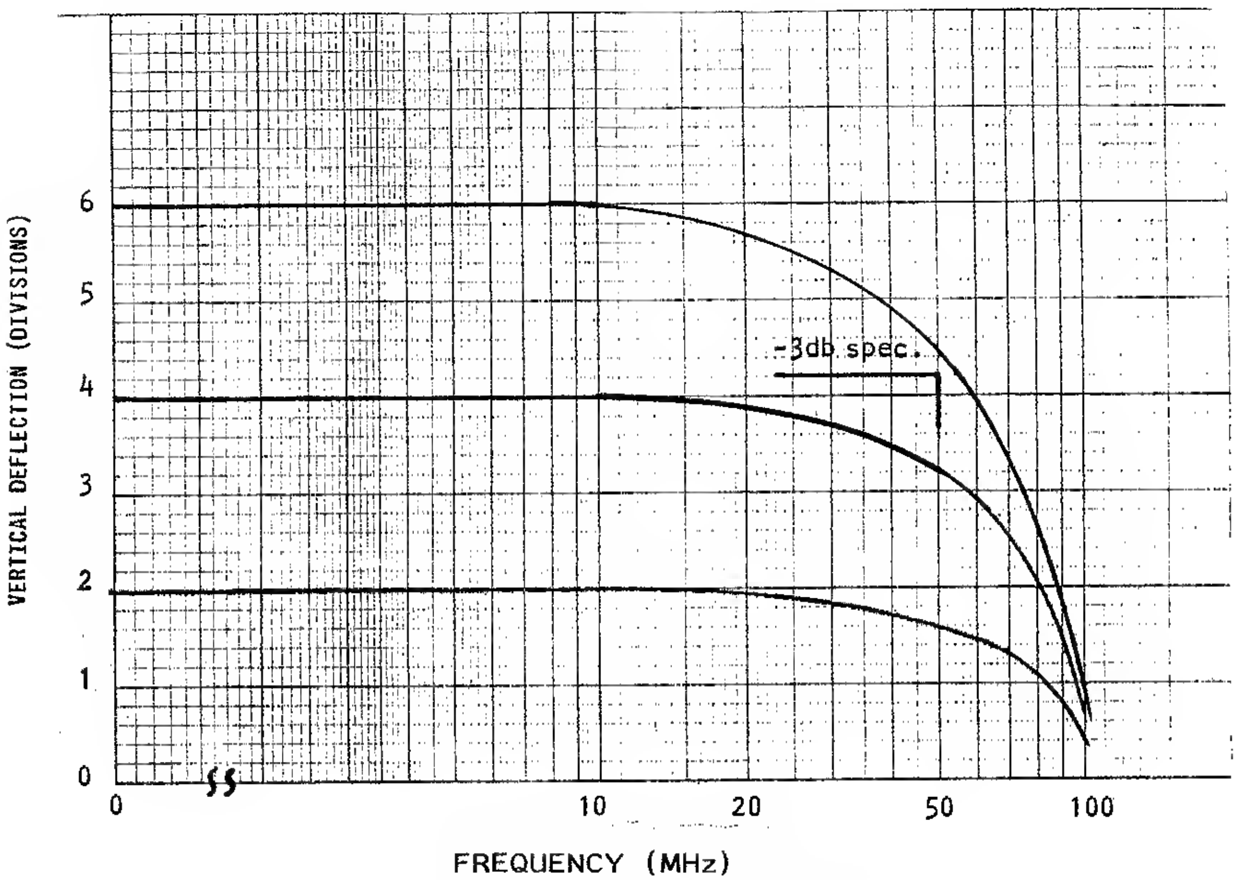


Fig 22. Typical Frequency Response of Channel 1 or 2
From 5mV to 20V/div

OPERATION NOTES

6.0 CIRCUIT DESCRIPTION

The circuit description is divided into the following sections:-

6.1 -6.5	Attenuators & Vertical Amplifiers
6.6 -6.14	Trigger & Timebase
6.15	Horizontal Amplifier
6.16-6.17	Power Supplies
6.18-6.19	CRT, Z Modulation Amplifier & Calibrator

6.1 ATTENUATOR Drg. 1896

NOTE: As CH2 & 2 attenuators are identical only CH1 is described.

Input signals to CH1 BNC socket are connected to the attenuator via S1 input selector switch. In the DC position, signals pass directly to the attenuator, in the AC position they pass via C1. In the GND centre position, the input signal is disconnected, but the amplifier input is grounded. The attenuator switch S2A-C is in two sections. S2A & B attenuates the input in a 1, 10, 100, 1000 sequence, whilst S2C attenuates the signal in a repetitive 1, 2, 4 sequence. The result of cascading the two sections is to attenuate signals in a 1, 2, 4, 10 sequence over the 12 steps. As no attenuation takes place in the amplifier itself, problems of DC drift affecting the trace position when the attenuator is switched do not occur in the **BWD 821.** Response and constant input capacity is maintained at each attenuator step by adjustable series and shunt capacitors.

6.2 INPUT AMPLIFIER CH1 Drg 1897

NOTE: As CH1 & 2 are similar, only CH1 is described except where differences occur.

The input amplifier is a balanced FET differential stage. Input protection is provided by R101 & C101 and reverse biased diodes D101 taken to -15V and D102 taken to +5.7V to prevent U101A gate from exceeding these limits. U101 A & B is a dual FET on a common substrate to minimise the effects of temperature drift on the trace position. RV102 Vernier gain control is located between the FET sources. R106 in series sets the maximum gain when RV102 is in the calibrated position. RV101 DC balance preset is adjusted for zero trace movement when RV102 is varied.

The position control RV104 is in the centre of a network consisting of R110 and R111.

Variation in the position of the wiper on RV104 will vary the ratio of the divider symmetrically and therefore the position voltage superimposed on the signal voltage at pins 1 and 14 of U102. S101A on the rear of RV102 vernier control reduces the position range 5:1 by shunting R112 and 113 across RV104 when x5 gain is switched in.

U101 A & B drain loads R108 & 109 are directly coupled to the inputs of the 733 IC amplifier U102.

The stage gain of U102 is preset by RV105. Switch S101B located on the rear of RV102 Vernier control switches in RV106 to shunt RV105 when the control knob is pulled out to increase the gain by x5. When S101 operates RV107 preset applies via R115 a voltage between +11.5V and ground to pin 4 of U102 to eliminate trace movement. The push pull output of amplifier U102 from pins 7 & 8 drives two circuits, trigger take off emitter follower U103A and the beam switching transistors U103B & C in IC U103.

6.3 BEAM SWITCH AMPLIFIERS

Two transistors in U103 are connected as a balanced series feedback pair with the collector of the switching transistor connected via R119 to the junction of R121 & 122 emitter resistors. RV108 and C107 in parallel provide H.F. compensation for CH1 amplifier. Beam switching to select CH1 or CH2 is controlled by half of U203 'D' flip flop. CH1 drive is via R128 to pin 12 of U103 and CH2 via R167 to pin 12 of U153.

The collectors of the transistor pair in U103 and the corresponding pair in U153 are joined together via S152A & B invert switch which determines the polarity of CH2 signal. The collectors are taken directly to the bases of Q133 and 135 vertical output amplifier.

6.4 BEAM SWITCH CIRCUIT

The beam switch is controlled by switch S201A & B.

When selecting CH1 the free running/alternate oscillator U202 is disabled by holding pin 8 of U203 and simultaneously, pin 8 of U202 HI, latching the output at 13 HI and output 9/12 LO. CH1 is turned on and CH2 off.

To select CH2 only, pin 1 of U202 and pin 10 of U203 are held HI. This causes pins 9/12 to go HI and pin 13 LO, so turning CH2 on and CH1 off.

In the ALT mode, pin 1 of U202 is held HI so pin 3 and 5 are LO. A positive pulse on pin from U304 time base gate via R335 at the start of the fly back period will cause pin 4 and 9 to go LO. As in 8 is held LO via R212 and R213 the output at pin 10 will go HI and via R213 apply the pulse to the clock input of U203 at pin 11. Outputs at 13 and 9/12 will alternate from HI to LO at each clock pulse and so switch the amplifiers on or off alternately at the end of each time base sweep.

In the CHOP mode, pin 8 of U202 is grounded via R213 and 212 so that sections A, B & C of U202 can operate as an oscillator at approx 300kHz.

The output pulse to pin 10 of U203 now causes the beam switch to change over every 3μsec approx and so switch the amplifiers at this rate. To eliminate the smear during the switching action, a portion of the oscillator output is applied to pin 13 of U202 via C203. The output at pin 11, a positive going pulse which overlaps the switching transient, is applied to the Z modulation amplifier to blank out the trace during this period.

6.5 OUTPUT AMPLIFIER

This is a push/pull circuit employing shunt feedback. Q133 and 135 are the main amplifiers with Q132 and 136 constant current transistors which operate as pull up stages at high frequencies and Q131 and 134 current feedback transistors. The circuit provides a low output impedance to drive the CRT deflection plates.

Current through Q133 & 135 is set by the emitter resistors of Q132 and 136 together with their respective base divider networks. A slightly lower standing current is also supplied via R133 and 143 via Q131 and 134 to U103 transistor pair so that when the amplifier is in its quiescent state, no current flows through the feedback resistors R136 or 146.

At low frequencies, Q132 and Q136 operate as constant current stages, so that only Q133 and Q135 operate as amplifiers. However, at high frequencies, Q132 and Q136 are driven via C131 and 133 respectively and supply a pull up current from C132 and 134 emitter bypass capacitors to the output load.

6.6 TRIGGER & X OUTPUTS

A transistor in U103 and 153 is connected as an emitter follower. R130 is the emitter load for CH1. CH2 output is also the drive for identical XY operation. Trigger take off is from the junction of R169 and 172, X take off is from RV158. R170 and RV159 adjust the current through R169 to set the X output to zero. CH1 or CH2 trigger signals are selected by S152C and supplied to the INT-EXT trigger select switch via C108.

6.7 TRIGGER & TIME BASE Drg 1898

Trigger Input

S301A selects either the internal trigger signal from C108 or external signals from the front panel input via R301, R302 with C302 in parallel.

S301B passes the signal selected by S301A in the out position or a line frequency signal from the power transformer secondary via R401 when depressed. The selected trigger is applied to U301A amplifier and transistor A in U302 array via C305. DC and low frequency signals are supplied by U301A and mixed with the HF signals via U302A. R307 forms the emitter load of U302A and the mixing load of U301A. As the inverting feedback input is taken from the mixing point to pin 2 of U301A the output DC level is identical to the input. The trigger signal is taken to S301C polarity selector and to U301B non-inverting input via R360. AC components of the signal are filtered out by C304. Trigger level control is applied to the inverting input via R304 where it is mixed with the feedback signal through R305. The resultant output is applied to S301C via R308.

Trigger Amplifier

Transistors U302B & C are a differential pair whose bases are connected to the + & - switch. When + is selected, the input signal passes to U302C and the level voltage to U302B. The converse applies when - is selected. Current through the differential pair is set by R314 and RV302 emitter load.

6.8 TRIGGER LATCH

U302B & C collectors are taken to inputs of two OR/NOR ECL gates U303 wired with R310 and R311 to provide positive feedback from the OR outputs to the same input pin as the transistor collectors. RV302 is adjusted so that the current through R310 and R311 when no signal is present, is just above the input threshold of each gate.

When a positive signal appears at the trigger input, it will cause U302C to conduct, taking current away from U302B. However, it will not cause U303B to conduct, as another input at pin 13 is held HI by the output of U303A. When the signal swings negatively, U302B conducts and assuming pins 4 & 12 are low, the current through R310 will cause the U303A gate to conduct. Its output will fall and via R310 it will latch the gate in a LO state. This now releases pin 13 of U303B gate, so that the next positive swing of the trigger signal makes gate U303B latch and both gates will remain in this condition until reset.

Both the OR & NOR outputs of U303B are taken to Q301. When awaiting a trigger signal the OR Output is positive to the NOR output and Q301 is reverse biased. When U303B latches, the outputs change over and Q301 is pulled into conduction, its collector rises and switches gate U304D input HI. This in turn causes its output to fall to enable the time base.

6.9 TV TRIGGER

When S301D is selected, a sync separator U302D is brought into operation to strip the sync pulses from the video waveform. U302C collector is switched via S301D from U303B gate to a collector load R317 and the signal developed across this is directly coupled to U302E. This transistor inverts the signal and it is then connected to U302D sync separator via R321 and C310. U302D is biased on by R320 so that negative going video signals will bias the transistor beyond cutoff and only sync signals will appear at its collector to latch U303B gate to which it is connected. C311 connected to ground via time base switch wafer S371A/R removes the high frequency line sync pulses from U302D collector load and leaves only frame pulses over time base speeds 0.1 sec to 0.1msec. At time base speeds 50usec to 0.2usec, S371A/R is open circuit, so that the line pulses remain to provide the trigger signal.

6.10 AUTO TRIGGER

When operating with a continuous trigger source, Q301 conducts at the start of each sweep to initiate the time base. It also charges C311 via D304, holding input 8 of U304C HI. Therefore, the output at 10 is LO and does not affect gate U304D. However, when a trigger signal is not present, Q301 does not conduct and C311 discharges through R328, pulling input 8 of U304C LO. As input 9 is held LO by U304B, the output at 10 will rise and pull U304D input HI, causing its output to fall and initiate a time base sweep. At the end of the sweep as previously described, U304B output rises and in addition to the hold-off function also takes pin 9 of U304C HI, causing its output to fall, so removing the gate drive from U304D, causing its output to go HI so allowing the return trace to start.

When the return trace and hold-off period is finished, U304B output falls, pulling pin 9 LO and unless a trigger signal has been received to charge up C311, the LO at input 9 will cause the output at 10 to rise, pulling gate U304D HI to initiate another sweep.

6.11 ALTERNATE DRIVE

The output of U304D provides the ALTernate drive for the vertical amplifier beam switch U202 & 203. The signal is fed into pin 6 of U202 via R332.

6.12 TIME BASE

U305 is the sawtooth integrator which is gated on by U304D and off by U304A. Hold off during the return trace is controlled by Q302 with C313, C314, C374-6 and R329 timing components. Sweep time is controlled by C377A-E capacitors and R382A-H charging resistors supplied by a negative voltage from RV373 time base vernier control.

Operation is as follows:-

Assuming the circuit is in a quiescent condition, the arrival of a trigger signal will drive Q301 into conduction as in para 6.8. As the collector rises to approx +3V, pin 12 of U304D will be pulled HI, causing its output to fall. When pin 13 is LO the divider R333 and 334 reverse bias D305 & D310.

U305 Bifet op amp is now left with a capacitor C377A-E as selected by S371B between output pin 6 and inverting input pin 2. (Pin 3 is grounded via S371A/F.) The timing resistor network R382A-H is also connected between pin 2 and a negative potential set by RV373 vernier control. As pin 2 is pulled negatively the output on pin 6 will rise. However, the timing capacitors C377 A-E will supply the inverted amplified output as negative feedback, maintaining a constant charging current producing an extremely linear sawtooth waveform.

The output continues to rise until R339 and RV303 divider pulls pin 2 of U304A gate HI. Output at 1 will fall pulling pin 5 of U304B LO and as pin 6 is already LO pin 4 switches to HI and latches the bistable pair in that condition via the direct connection to pin 3 of U304A.

The output of U304B resets U303A & B by taking pins 4 & 12 above the gate threshold voltage via R327. This in turn unlatches Q301, its collector falls so that it no longer holds pin 12 of U304D HI. As pin 9 of U304C has been taken HI by U304B output, pin 10 will fall so both inputs of U304D are LO, pin 13 switches HI and diode D305 is pulled into conduction by R333. When the inverting input of U305 is pulled positively its output at 6 will fall and discharge the timing capacitors. A quiescent state is reached when the pull down current from U305 via diode D310 equals the current through R333.

During the sweep period, Q302 was pulled into conduction by base current through R340, clamping capacitors connected to Q302 collector at +0.2V. However, when U305 output falls to zero, Q302 is turned off, allowing the capacitors to be pulled positively by R329 which is connected to +15V. When the voltage on Q302 collector and pin 6 of U304B reaches approx +3V, U304B switches over, its output falls and pulls pin 3 of U304A LO. As pin 2 is already LO, the output at 1 switches to HI, pulls pin 5 HI and the bistable pair again are latched. With output at pin 4 LO, the trigger latch U303 is released ready for the next trigger signal, pin 9 of U304C is set LO releasing the Auto gate. If C311 has not been charged up via D304 due to a lack of trigger signals, the two inputs will be LO, its output at 10 will be HI and pull pin 11 of U304D HI, switching 13 LO, releasing D303 & 310 so starting another sweep. If C311 was charged, the output at U304C pin 10 will remain LO and the next sweep will commence when U303 receives a signal, latches, pulls Q301 into conduction which in turn pulls pin 12 of U304D HI and starts the next sweep.

6.13 MIX-MAG

When the time base vernier control RV373 is in its normal position (pushed in), voltage is supplied to it by U371B unity gain op-amp whose output is set by the divider R376, RV372 and R378 connected to pin 5 non-inverting input. In this condition Q371 is pulled into conduction by R379 being returned to approx -1.5V. This causes the collector which is connected to U371A inverting input to rise to approx +5.7V. As the non-inverting input does not rise above +3V the output at pin 1 will fall to approx -14V disconnecting zener diode D372 so removing the drive from Q372 base.

When the vernier control is pulled out to engage MIX-MAG, S372 connects RV373 to the +5.7V rail and the timing resistors R382A-H directly to U371B. As the base of Q371 is at the same potential as its emitter it is cut off and U371A comparator is now controlled by the sweep sawtooth voltage applied via R372 and the voltage on RV373 via divider R377, R373 and R374. With the vernier fully clockwise (cal position) the input on pin 2 of U371A remains positive to the sweep input voltage on 3 so no change occurs. AS RV373 is rotated the voltage on 2 falls until the sweep voltage on 2 causes U371A to switch. Pin 1 rises and via R375, C373 and D372 pulls Q372 into conduction. Q372 saturates and pulls current through R381 collector load, disconnects U371B output via diode D373 and applies approx -15V to the time base timing resistors R382A-H. The tenfold increase in charging current through R328A-H increases the time base speed x10 and magnifies the selected right hand portion of the trace. During the return trace the circuit reverts back to its original condition.

6.14 XY OPERATION

When the time base switch S371 is turned fully clockwise to XY, the timing capacitors C377 are replaced with a resistive feedback network consisting of R371 and RV371. R383 provides a centering voltage. The junction of R371 and RV371 are taken to S371A/R, where the rotor contact connects it back to S371B/F and then via the wiper arm to U305 inverting input. RV158 adjusts the gain and sets the X calibration, RV371 is adjusted for phase shift.

The X signal from CH2 taken from the junction of R169 and 170 to RV158 and then to pin 3 of U305 normally grounded by S371A/R wafer, but disconnected in the XY position.

6.15 HORIZONTAL AMPLIFIER

The amplifier transistors Q304, 305, 307, 308, 310 and 311 are configured in a push pull series/shunt feedback circuit.

The input signal is applied to Q304 whilst the horizontal positioning voltage from RV304 is connected to the other side of the amplifier Q305 via emitter follower Q306.

Signals developed across Q304 and 305 collector loads R352 and 353 are applied directly to Q308 and 310 bases. RV307 balance control eliminates movement of the waveform when S303 x1/x10 magnification switch is operated. This switch changes the feedback ratio applied to Q304 and 305 emitters to change the gain.

The collector loads of the deflection amplifier Q308 is R350 and 351 in series, whilst Q310 load is R354. Emitter followers Q307 and 311 connected in series with Q308 and 310 supply the deflection plate voltage and the feedback currents via R348 and 349.

6.16 POWER SUPPLIES

AC input voltage is taken to S401 on-off power switch (located on the rear of RV424 intensity control).

It then passes through input fuses F401 & 402 to the transformer T401. The two primary windings are connected in series for 195 to 264V operation and in parallel for 98 to 132V. The centre tapped secondary winding is full wave rectified to supply + & -22V (approx). C401 filters the +ve rail and C402 the negative. The rails are stabilised by U401 & U402 to provide + & - 15V for direct connection to the amplifier and time base circuits and via resistors R421 and 422 with additional filtering by C421 to the DC to DC converter circuit.

6.17 DC-DC CONVERTER

The +90V, EHT rails and CRT heater supply are supplied from T421 transformer. This circuit uses a push/pull direct drive feedback oscillator operating at 22kHz approx, consisting of Q421 and 422 transistors with R423, R424 and D421 base supply divider. The +90V HT supply is full wave rectified by D422 and D423 and filtered back to the +15V rail to which the winding is connected. Additional filtering is provided by R445 and C323 on the main PCB.

The negative EHT winding is half wave rectified by D424 and filtered by C431, R431 and C432 before being applied to the CRT cathode. To provide additional stabilisation of the -1440V rail the ground end of the EHT winding is taken through transistor Q423 to ground. The negative EHT voltage is applied across the divider R427, RV421 and R428 and then returned to the +90V rail. Any variation at the junction of R428 and RV421 is fed to Q424 base and then via its emitter to Q423 base to control its conduction and stabilise the supply against changes in beam current.

The PDA voltage is obtained by a voltage tripler C427, C428 and C429, D425, D426 & D427. The +4700V supply is filtered by R432 and C430 and supplied to the PDA via the CRT side connector.

6.18 CRT & Z MODULATION AMPLIFIER

The 140CG P31 domed mesh PDA CRT is supplied by the -1440V rail directly to its cathode. Its grid voltage is obtained by demodulating a signal derived from the 22kHz converter winding. Focus voltage is tapped off the divider R433, RV423 and R434. Geometry and astigmatism voltages are taken from low voltage rails or from preset potentiometers connected across them.

The Z or intensity modulation circuit derives its voltage from the +90 Volt transformer output winding. It is taken through R430 to D430 which through RV422 preset sets the maximum modulation voltage available to blank the CRT.

Q425, 426 and 427 modulation amplifier is a shunt feedback stage. Q425 supplies a constant current at low frequencies, Q427 emitter follower drives both Q426 amplifier directly and Q425 via C437 to provide a push/pull drive at high fequencies. Input signals to Q427 base are supplied via D432 which prevents Q426 amplifier from saturating. Four signals - intensity voltage, external Z input via R443, time base blanking via R330 and chopped blanking via R208 are combined at the current input drive to Q427.

The combined current drive from the four sources causes Q426 collector to swing from approx +5V to +50V to modulate via D431 the clipped 22kHz square wave at R430 and D430 junction.

High frequency signals drive the CRT grid directly via C435 whilst low frequency modulated signals are supplied by C434 to D428 and D429 demodulator diodes.

D428 conducts on positive signals DC restoring the waveform to the CRT cathode which is then conducted via D429 to combine with the AC coupled component at the CRT grid.

6.19 CALIBRATOR

The second 'D' flip flop U203B is connected to Q201 to form a 1kHz free running oscillator.

In operation when $\overline{Q}$ output at pin 2 goes LO, the emitter of Q201 falls to +3.5V and R218 proceeds to discharge C206 until Q201 is pulled into conduction. Its collector draws current through R220 pulling the reset input of U203B at pin 4 HI. $\overline{Q}$ now rises and via R218 & 219 plus R215 and 216 via Q201 base-emitter diode charges C201 positively until the base of Q201 is pulled positive to its emitter when it ceases to conduct. R220 pulls pin 4 of U203B LO, $\overline{Q}$ follows and the cycle repeats.

7. ADJUSTMENTS & MAINTENANCE

Should the BWD 821 require re-calibration, as for example after repairs, etc. a number of preset controls are fitted which may be adjusted as detailed in the following section.

Before removing the cover, disconnect the instrument from the mains. Remove the four screws holding the feet, the countersunk grounding screw and the two side screws. The cover may then be slipped off to the rear of the instrument.

To aid fault finding and alignment, the voltages and waveforms present at various points are shown on the circuits.

7.1 ALIGNMENT PROCEDURE

Before attempting re-alignment of any section of this Oscilloscope, check the instrument's general operating characteristics and correct any apparent faults. Also check DC rails as variation in supply voltages caused by a fault may result in miscalibration.

7.2 GENERAL CHECK OF CONTROLS

a. Intensity:	Linear control over intensity range.
b. Focus:	Approx. centre with adjustment either side.
c. x1-x10 Hor.Mag:	Trace should expand equally either side of centre.
d. Vert. Positions:	Traces should move equally off screen above and below centre.
e. Trigger Level:	With atten. at 0.1V feed CAL signal into CH1 and CH2 inputs, check AUTO and Level Select operation.
f. + - Switch:	Set up as for e, trigger point should change over as indicated by switch.

7.3 EQUIPMENT REQUIRED FOR COMPLETE CALIBRATION

DVM with High Voltage Probe:	
Pulse Generator:	3nsec Rise Time.
Voltage Calibrator:	1mV to 100V p- 0.25% accuracy.
Sine Wave Generator:	1Hz to 1MHz (BWD 141 or BWD 160A).
Constant Amplitude Generator:	50kHz to 50MHz. 3% amplitude level accuracy.
Time Marker Generator:	40nsec to 1 sec/pulse. 0.1% accuracy.

7.4 POWER SUPPLIES

With AC power applied, switch the instrument on and allow it to stabilise for five minutes before making any adjustments. The + & - 15V rails are set by the regulator I.C.'s and are not adjustable. They should be within +/-.6V. +90V is not adjustable being supplied by the converter transformer T421. The voltage should be 90V +/-5V.

The +5.7V rail is also preset by fixed components R201 & 202 supplying the reference to IC U201 +5.7V regulator.

EHT The -ve CRT supply is set to -1440V +/-10V by RV421 on the converter board. The voltage should be monitored at the CRT cathode pin on the converter board. (Brown wire).

DANGER The PDA +4.7kV voltage remains after the instrument has been switched off as the only discharge path is reverse diode or filter capacitor leakage.

Therefore discharge the PDA supply at the rear converter power supply board before working on it via a 1Mohm resistor to chassis -

NEVER DISCHARGE DIRECTLY TO CHASSIS VIA A SCREWDRIVER, ETC. AS THIS MAY DAMAGE THE INSTRUMENT.

7.5 CRT EHT & TRACE ALIGNMENT

Trace rotation preset on rear panel should be set so that a single undeflected trace aligns precisely with the horizontal centreline of the graticule.

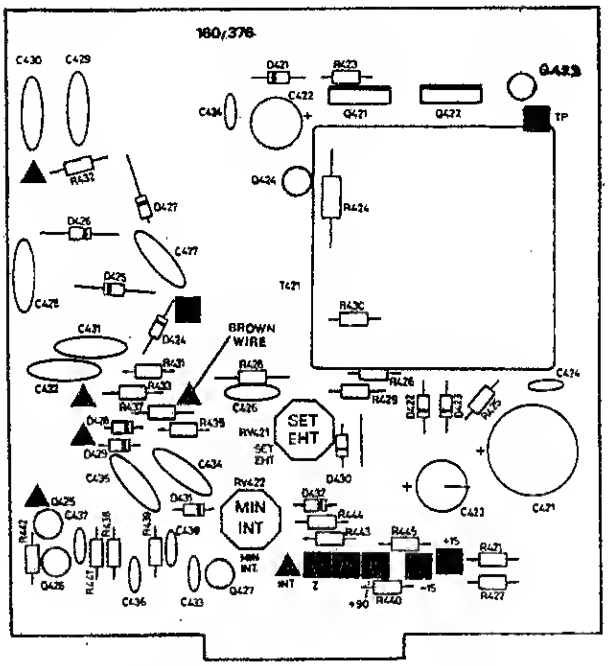


Fig 7-1 Converter & Blanking PCB

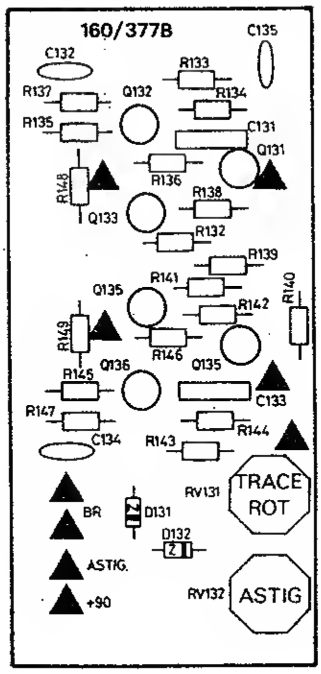


Fig 7-2 Vertical Output PCB

Next feed a 1kHz sine wave signal into the CH1 and adjust the waveform to fill screen. Time base to 1msec, VERNIER CAL.

Adjust the rear panel astigmatism preset control in conjunction with the FOCUS control to obtain the best resolution over the entire screen area at normal viewing intensity. Geometry voltage is fixed at +45V approx.

Intensity is adjusted by turning the front panel intensity control to minimum and adjusting RV422 to just blank the trace when the time base is set to 1 sec/div.

7.6 VERTICAL ALIGNMENT

a. Centre the trace with the vernier at CAL, then turn the verner counter clockwise. If the trace moves, recentre it with the preset balance control RV101 for CH1 and RV151 for CH2. Return verniers to CAL and repeat adjustment of RV101 and RV151 until no movement occurs.

b. Switch to CH1 only. Turn vernier to CAL and attenuator to 5mV/div. Feed in a 1kHz 25mV p-p calibration square wave. Adjust RV105 for 5 div deflection.

c. With the vernier control to CAL pull out the knob for x5 gain, decrease the input signal to 5mV p-p. Now adjust RV106 for 5 div deflection.

d. Repeat (b & c) for CH2, setting RV155 for 5mV sensitivity and RV156 at 1mV/div.

e. Whilst switched to x5 gain, remove input signal and check that the position control moves the trace equally above and below the centre line. Correct with RV103 CH1 or 153 CH2 if necessary. Next centre the trace and push the vernier in for x1 gain. If trace moves correct with RV107 CH1 or RV157 CH2. Repeat until movement is eliminated.

f. With attenuators at 5mV and vernier to CAL apply a correctly terminated 1MHz 3nsec rise time square wave to CH1 input. Set amplitude for 6 div deflection. Adjust RV108 and C107 for best square wave response with a sharp wave front, but minimum aberation at the corner.

Repeat for CH2 adjusting RV160 and C156.

g. Bandwidth check. Apply a 50kHz reference sine wave to CH1. Set attenuator to 5mV/div. Set amplitude to 6 div. Increase oscillator frequency. Amplitude should not drop below 4.2 div deflection (-3db) at 50MHz. Repeat for CH2. Repeat para f. for a sharper corner if bandwidth is low.

h. Repeat f. and g. with vernier pulled out for x5 gain. Adjust C109B (CH1) or C157B (CH2) for best response. Level should not drop below 4.2 div from a 6 div reference before 20MHz on either channel.

7.7 CALIBRATOR ADJUSTMENT

When CH1 is correctly calibrated against an external standard, set its attenuator to 0.1V and the input selector to DC. Feed in the 0.5V Cal signal from the front panel socket and adjust for 5 div deflection by

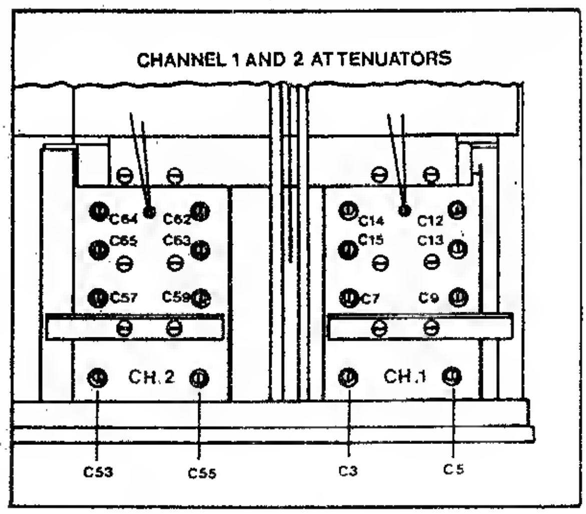


Fig 7-3 CH1 & 2 Attenuators

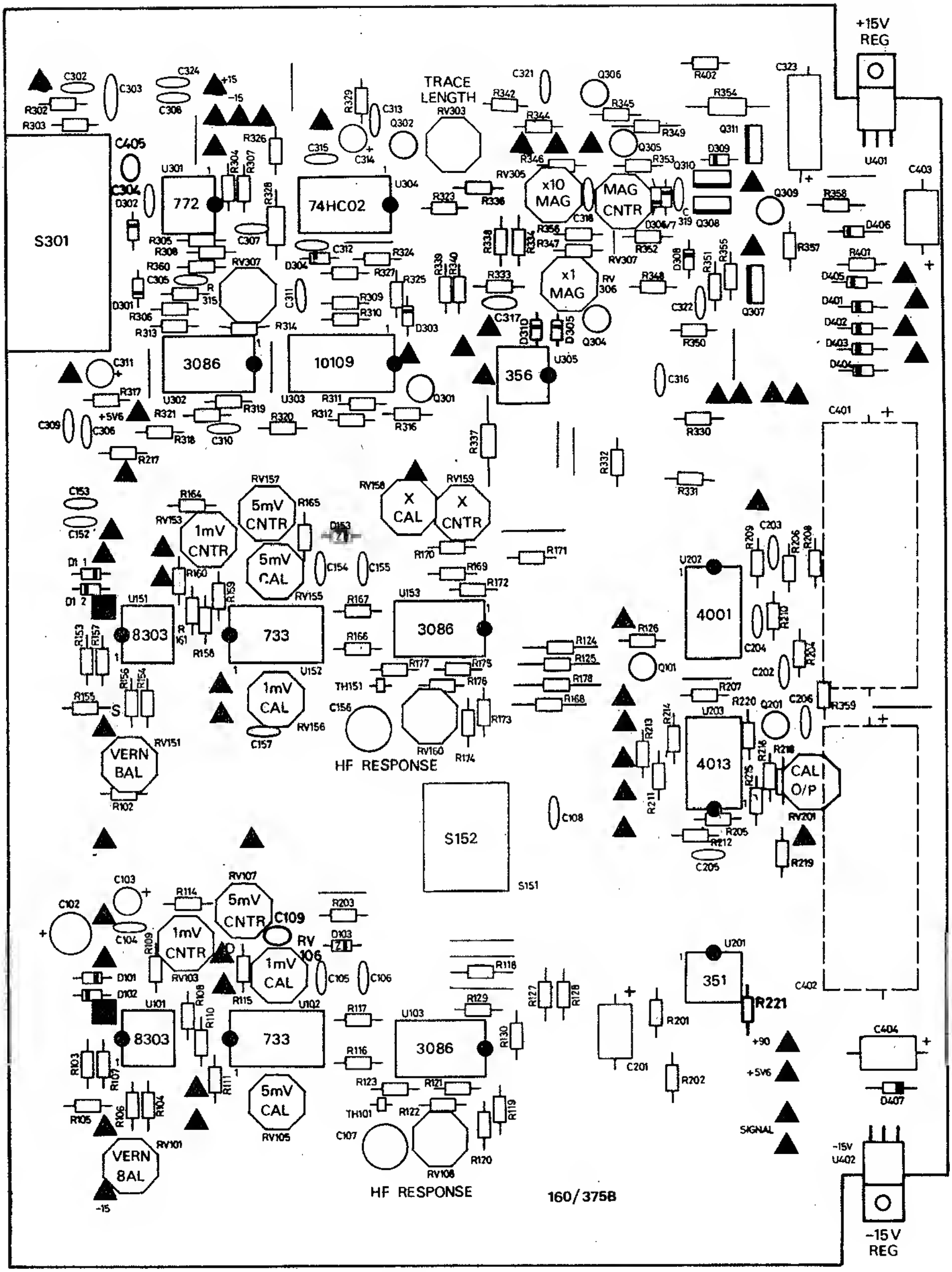
Fig 26. CH1 & 2 Attenuators

7.8 ATTENUATOR ALIGNMENT

The following figures indicate the input voltages, attenuator settings and the capacitors, which compensate the attenuator response. Figures in brackets are for CH2.

Attenuator steps not listed have no adjustment. They are automatically aligned at other settings.

ATTENUATOR SETTING	INPUT VOLTAGE	ADJUST FOR SQUARE WAVE		ADJUST FOR INPUT CAPACITANCE	
5mV	–	–	–	–	
10mV	50mV	C14	(64)	–	
20mV	100mV	C12	(62)	C9	(59)
0.1	0.5V	C15	(65)	–	
0.2	1V	C13	(63)	–	
0.5	2.5V	C3	(53)	C5	(55)



Model BWD B21 Main P.C.B.

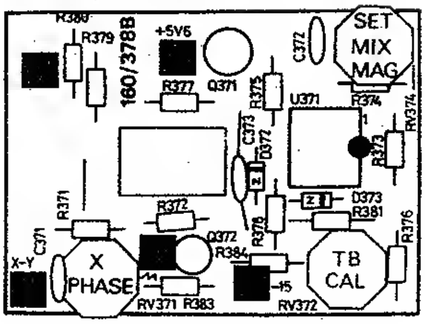


Fig 7-5 Mix-Mag PCB

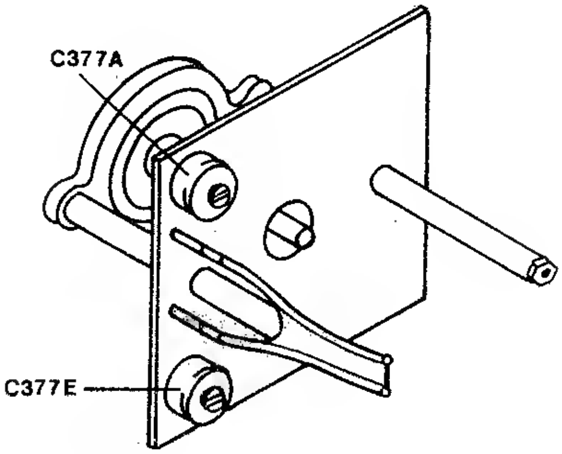


Fig 7-6 Timebase Switch

7.9 TIME BASE ALIGNMENT

a. Set time range to 1msec/div, pull out vernier control to MIX-MAG position, turn vernier fully counter clockwise, adjust RV374 until unmagnified section of trace is 1 div long. Apply 100usec pulses to vertical amplifier and lock display with level control. Adjust RV306 horizontal amplifier x1 mag gain control for 1 pulse/div.

b. Return vernier control to CAL and push knob in for normal operation. Set trace length to 11 div by RV303.

c. Turn time range to 1msec/div, the vernier remaining in Cal position. Apply 1msec pulses and lock display. Adjust RV372 on MIX-MAG board for 1 pulse/div.

d. Increase input pulses to 100usec then pull out the horizontal position-control for x10 magnification. Adjust RV305 for 1 pulse per graticule division. Return to x1 magnification and reduce the pulse rate to 5msec. Centre the leading edge of the middle pulse on the graticule centre line. Pull out the x10 mag knob without turning it. The pulse should still remain on the centre line. If it moves recentre with the position control, push to x1 and then recentre with RV307. Repeat if necessary to eliminate movement.

e. Turn time base to 0.2usec/div. Adjust C377A, on rear of time base switch for 1 per div of 0.2usec pulses (5MHz).

f. Turn time base to 10usec/div and apply 10usec pulses. Adjust C377E on rear to time base switch for calibration. Check calibration from 10usec to .5usec and set C377E for best overall calibration.

7.10 XY ADJUSTMENT

a. Switch Vertical Display to CH1. Position CH1 trace in centre of screen (AUTO operation, no input signal). Now turn time base switch to XY position and pull out horizontal position control for x10 mag, control centred.

Next set both attenuators to 5mV/div, vernier to Cal. DC coupled, then feed into CH1 & CH2 a 1kHz sine wave signal from a constant amplitude generator and adjust input to 6 div deflection, to produce a diagonal line on the CRT. Centre trace on CRT with RV159.

b. Calibration. Switch CH1 to GND to present a horizontal line on the CRT. Adjust RV158 for 6 div deflection.

c. Phase shift. Switch CH1 to DC. Set the input to 200kHz then adjust RV371 on MIX-MAG board for minimum deviation from a straight line.

d. Reset a and b for centering and calibration.

e. Horizontal bandwidth. Switch CH1 to GND to leave a horizontal line on the CRT. From a reference of 50kHz at 6 div the trace should not drop below 4.2 div before 1.5MHz.

7.11 TRIGGER SENSITIVITY

a. Operate the oscilloscope in the dual trace mode with the time base at 5mSec/div, normal +ve internal trigger with level select knob centred. Connect a 50Hz sine wave to CH1 and adjust for 1 div deflection. Lock trace with trigger level control. Now reduce signal amplitude adjusting RV302 to maintain a stable lock with no double triggering until a deflection of 0.4 div can be locked. Change the frequency and polarity to ensure double triggering does not occur.

b. Trace should remain locked over a frequency range from 5Hz to 50MHz with 1 div deflection. When signal level is increased, upper frequency limit will extend past 50MHz.

c. With a 50Hz sine wave input, increase deflection to 8 div. Check that level control operates over the full range either + or - polarity is selected.

d. Parallel the input signal via a T-piece to both CH1 and EXT TRIG input socket. Select EXT TRIG, then adjust signal level to 0.25V p-p. EXT TRIG should operate from 5Hz to 50MHz.

7.12 T.V. TRIGGER CHECK

Apply a composite video waveform to CH1. Adjust amplitude for 2 div deflection, time base to 2msec, TV trigger button selected, Trigger Level to AUTO. The frame signal will be displayed. Increase time base speed to 50usec or faster and the line signal will be displayed. Trigger Level may be employed to lock video signals 2 div to 8 div deflection.

The **BWD 821** Oscilloscope is now fully aligned.

8.1 GUARANTEE

This equipment is guaranteed for a period of twelve (12) months from the date of purchase against faulty materials and workmanship.

8.2 REPLACEMENT PARTS

Spares are normally available from the manufacturer BWD Industries Ltd. When ordering it is necessary to indicate the model and serial number of the instrument. If exact replacements are not to hand, locally available alternatives may be used, provided they possess a specification not less than, or physical size not greater than the original components.

8.3 Many of the semi conductors in Model BWD 821 have been factory selected for the particular position they occupy. It is most important that the Handbook Parts List be consulted before replacing any semi conductors since selected or matched devices can be obtained **ONLY** from the manufacturer BWD Industries Ltd. or their representatives.

8.4 As the policy of BWD Industries Ltd. is one of continuing research and development, the Company reserves the right to supply the latest equipment and make amendments to circuits and parts without notice.

PARTS LISTS

Component Designations:

A	Assembly	Q	Transistor
C	Capacitor	R	Resistor
D	Diode	RV	Variable Resistor
E	Misc. Elec. Part	S	Switch
F	Fuse	T	Transformer
J	Jack (Socket)	TH	Thermistor
L	Indicator	VDR	Voltage Dependent Resistor
P	Plug		

Abbreviations:

Amp	Ampere	MPC	Metalised Polyester Capacitor
CF	Carbon Film	NPO	Zero Temperature Co-efficient
c	Carbon	ns	Nano-second
CDS	Ceramic Disc	p	Peak
cer	Ceramic	pF	Pico Farad = 10^{-12}F
DPST	Double Pole Single Throw	preset	Internal Preset
DPDT	Double Pole Double Throw	PYE	Polyester
elec	Electrolytic	pot	Potentiometer
FET	Field Effect Transistor	PCB	Printed Circuit Board
kHz	Kilohertz = 10^3Hz	PIV	Peak Inverse Voltage
k	kilohm = 10^3ohm	PYS	Polystyrene
Lin	Linear	p-p	Peak to Peak
Log	Logarithmic Taper	R	Ohms
m	Milli = $\times 10^{-3}$	rot	Rotary
MHz	Mega-hertz = 10^6Hz	rms	Root Mean Squared
MF	Metal Film	si	Silicon
mA	Milliampere = 10^{-3}Amp	Ta	Tantalum
M	Megohm = 10^6ohm	tol	Tolerance
mfr	Manufacturer	trim	Trimmer
MO	Metal Oxide	V	Volts
MHT	Polyester/Paper Capacitor	var	Variable
		W	Watt

Manufacturer's Abbreviations:

ALPS	Alps Electronics	MOT	Motorola Semiconductor Inc.
BWD	BWD Industries Ltd.	NS	NS Electronics Pty Ltd
ELN	Elna Capacitors (Soanar)	NSF	NSF Limited
F	Fairchild	PH	Philips Industries Limited
IRH	IRH Components P/L	SON	Soanar Electronics P/L
ERIE	Erie Capacitors	SIEM	Siemens Industries Limited
NOBLE	Noble Electronics	STET	Stettner Capacitors Limited

CCT REF	DESCRIPTION				MFR.	PART NO.
	RESISTORS					
R1	10R	5%	1/4W	MF		
R2	990k	1%	1/4W	MF		
R3	10k1	1%	1/4W	MF		
R4	111k	1%	1/4W	MF		
R5	900k	1%	1/4W	MF		
R6	500k	1%	1/4W	MF		
R7						
R8	750k	1%	1/4W	MF		
R9						
R10	333k	1%	1/4W	MF		
R11	1M	1%	1/4W	MF		
R12	1M	1%	1/4W	MF		
R13	33R	5%	1/4W	MF		
R14	1M	1%	1/4W	MF		
R15	33R	5%	1/4W	MF		
R16	56R	5%	1/4W	MF		
R51	10R	5%	1/4W	MF		
R52	900k	1%	1/4W	MF		
R53	10k1	1%	1/4W	MF		
R54	111k	1%	1/4W	MF		
R55	900k	1%	1/4W	MF		
R56	500k	1%	1/4W	MF		
R57						
R58	750k	1%	1/4W	MF		
R59						
R60	333k	1%	1/4W	MF		
R61	1M	1%	1/4W	MF		
R62	1M	1%	1/4W	MF		
R63	33R	5%	1/4W	MF		
R64	1M	1%	1/4W	MF		
R65	33R	5%	1/4W	MF		
R66	56R	5%	1/4W	MF		
R101	220k	5%	1/4W	MF		
R102	39R	5%	1/4W	MF		
R103	10k	5%	1/4W	MF		
R104	10k	5%	1/4W	MF		
R105	39R	5%	1/4W	MF		
R106	220R	5%	1/4W	MF		
R107	4k7	5%	1/4W	MF		
R108	680R	5%	1/4W	MF		
R109	680R	5%	1/4W	MF		
R110	56k	5%	1/4W	MF		
R111	56k	5%	1/4W	MF		
R112	1k2	5%	1/4W	MF		
R113	1k2	5%	1/4W	MF		
R114	1k2	5%	1/4W	MF		
R115	47k	5%	1/4W	MF		
R116	39R	5%	1/4W	MF		
R117	39R	5%	1/4W	MF		
R118	10R	5%	1/4W	MF		
R119	560R	5%	1/4W	MF		
R120	160R	5%	1/4W	CF		
R121	150R	5%	1/4W	MF		

CCT REF	DESCRIPTION				MFR.	PART NO.
R122	150R	5%	1/4W	MF		
R123	470R	5%	1/4W	MF		
R124	390R	5%	1/4W	MF		
R125	390R	5%	1/4W	MF		
R126	47k	5%	1/4W	MF		
R127	15k	5%	1/4W	MF		
R128	2k2	5%	1/4W	MF		
R129	82R	5%	1/4W	MF		
R130	3k9	5%	1/4W	MF		
R131	22k	5%	1/4W	MF		
R132	22k	5%	1/4W	MF		
R133	4k7	5%	1/4W	MF		
R134	47k	5%	1/4W	MF		
R135	10k	5%	1/4W	MF		
R136	3k3	5%	1/4W	MF		
R137	820R	1%	1/4W	MF		
R138	68R	1%	1/4W	MF		
R139	18k	5%	1/4W	MF		
R140	10R	5%	1/4W	MF		
R141	220R	5%	1/4W	MF		
R142	68R	5%	1/4W	MF		
R143	4k7	5%	1/4W	MF		
R144	47k	5%	1/4W	MF		
R145	10k	5%	1/4W	MF		
R146	3k3	5%	1/4W	MF		
R147	820R	5%	1/4W	MF		
R148	8k2	5%	1/4W	MF		
R149	8k2	5%	1/4W	MF		
R150						
R151	220k	5%	1/4W	MF		
R152						
R153	10k	5%	1/4W	MF		
R154	10k	5%	1/4W	MF		
R155	82R	5%	1/4W	MF		
R156	220R	5%	1/4W	MF		
R157	4k7	5%	1/4W	MF		
R158	680R	5%	1/4W	MF		
R159	680R	5%	1/4W	MF		
R160	56k	5%	1/4W	MF		
R161	56k	5%	1/4W	MF		
R162	1k2	5%	1/4W	MF		
R163	1k2	5%	1/4W	MF		
R164	1k2	5%	1/4W	MF		
R165	47k	5%	1/4W	MF		
R166	39R	5%	1/4W	MF		
R167	39R	5%	1/4W	MF		
R168	15k	5%	1/4W	MF		
R169	3k9	5%	1/4W	MF		
R170	4k7	5%	1/4W	MF		
R171	10R	5%	1/4W	MF		
R172	82R	5%	1/4W	MF		
R173	560R	5%	1/4W	MF		
R174	160R	5%	1/4W	CF		
R175	150R	5%	1/4W	MF		
R176	150R	5%	1/4W	MF		
R177	470R	5%	1/4W	MF		
R178	2k2	5%	1/4W	MF		
R179	22k	5%	1/4W	MF		

CCT REF	DESCRIPTION				MFR.	PART NO.
R201	10k	5%	1/4W	MF		
R202	6k2	1%	1/4W	MF		
R203	680R	5%	1/4W	MF		
R204	39R	5%	1/4W	MF		
R205	39R	5%	1/4W	MF		
R206	47k	5%	1/4W	MF		
R207	330k	5%	1/4W	MF		
R208	4k7	5%	1/4W	MF		
R209	10k	5%	1/4W	MF		
R210	10k	5%	1/4W	MF		
R211	47k	5%	1/4W	MF		
R212	10k	5%	1/4W	MF		
R213	47k	5%	1/4W	MF		
R214	10k	5%	1/4W	MF		
R215	9k1	1%	1/4W	MF		
R216	47k	5%	1/4W	MF		
R217	330k	5%	1/4W	MF		
R218	150k	5%	1/4W	MF		
R219	180k	5%	1/4W	MF		
R220	68k	5%	1/4W	MF		
R221	10R	5%	1/4W	MF		
R301	180R	5%	1/4W	MF		
R302	470k	5%	1/4W	MF		
R303	560k	5%	1/4W	MF		
R304	47k	5%	1/4W	MF		
R305	4k7	5%	1/4W	MF		
R306	180k	5%	1/4W	MF		
R307	1k	5%	1/4W	MF		
R308	39R	5%	1/4W	MF		
R309	2k7	5%	1/4W	MF		
R310	180R	5%	1/4W	MF		
R311	180R	5%	1/4W	MF		
R312	2k7	5%	1/4W	MF		
R313	39R	5%	1/4W	MF		
R314	2k2	5%	1/4W	MF		
R315	39R	5%	1/4W	MF		
R316	180R	5%	1/4W	MF		
R317	1k2	5%	1/4W	MF		
R319	3k9	5%	1/4W	MF		
R319	2k7	5%	1/4W	MF		
R320	2M7	5%	1/4W	CF		
R321	10R	5%	1/4W	MF		
R322						
R323	3k9	5%	1/2W	MF		
R324	82R	5%	1/4W	MF		
R325	1k	5%	1/4W	MF		
R326	39k	5%	1/4W	MF		
R327	4k7	5%	1/4W	MF		
R328	5M6	5%	1/4W	CF		
R329	56k	5%	1/4W	MF		
R330	3k3	5%	1/4W	MF		
R331	4k7	5%	1/4W	MF		
R332	12k	5%	1/4W	MF		
R333	3k9	5%	1/4W	MF		
R334	1k5	5%	1/4W	MF		
R335						
R336	5M6	5%	1/4W	CF		

CCT REF	DESCRIPTION				MFR.	PART NO.
R337	39R	5%	1/4W	MF		
R338						
R339	1k5	5%	1/4W	MF		
R340	47k	5%	1/4W	MF		
R341	33k	5%	1/4W	MF		
R342	33k	5%	1/4W	MF		
R343	6k8	5%	1/4W	MF		
R344	330R	5%	1/4W	MF		
R345	22k	5%	1/4W	MF		
R346	82R	5%	1/4W	MF		
R347	1k	5%	1/4W	MF		
R348	39k	5%	1/4W	MF		
R349	39k	5%	1/4W	MF		
R350	10k	5%	1/4W	MF		
R351	8k2	5%	1/4W	MF		
R352	1k	5%	1/4W	MF		
R353	1k	5%	1/4W	MF		
R354	18k	5%	1W	MF		
R355	220R	5%	1/4W	MF		
R356	3k9	5%	1/4W	MF		
R357	12k	5%	1/4W	MF		
R358	9k1	1%	1/4W	MF		
R359	10R	5%	1/4W	MF		
R360	1M	5%	1/4W	MF		
R371	10k	5%	1/4W	MF		
R372	2k2	5%	1/4W	MF		
R373	680k	5%	1/4W	MF		
R374	470k	5%	1/4W	MF		
R375	10k	5%	1/4W	MF		
R376	1k	5%	1/4W	MF		
R377	100k	5%	1/4W	MF		
R378	10k	5%	1/4W	MF		
R379	220k	5%	1/4W	MF		
R380	2k2	5%	1/4W	MF		
R381	10k	5%	1/4W	MF		
R382	A-H	THICK FILM NETWORK			BWD	010-010
R383	120k	5%	1/4W	MF		
R384	3k9	5%	1/4W	MF		
R385						
R386						
R401	560k	5%	1/4W	MF		
R402	18k	5%	1/4W	MF		
R403	1k5	5%	1/4W	MF		
R421	2R2	5%	1/4W	MF		
R422	2R2	5%	1/4W	MF		
R423	33R	5%	1/4W	MF		
R424	2k2	5%	1W	MF		
R425	82k	5%	1/4W	MF		
R426	150k	5%	1/4W	MF		
R427	560k	5%	1/4W	MF		

CCT REF	DESCRIPTION				MFR.	PART NO.
R428	10M	5%	1/2W	MF	PH	VR 37
R429						
R430	330k	5%	1/4W	MF		
R431	22k	5%	1/4W	MF		
R432	2M2	5%	1/2W	MF	PH	VR 37
R433	2M2	5%	1/2W	MF	PH	VR 37
R434	8M2	5%	1/2W	MF	PH	VR 37
R435	10k	5%	1/4W	MF		
R436						
R437	10M	5%	1/4W	CF		
R438	12k	5%	1/4W	MF		
R439	33k	5%	1/4W	MF		
R440	10k	5%	1/4W	MF		
R441	82k	5%	1/4W	MF		
R442	82k	5%	1/4W	MF		
R443	10k	5%	1/4W	MF		
R444	15k	5%	1/4W	MF		
R445	10R	5%	1/4W	MF		
R446	820R	5%	1/4W	MF		

CAPACITORS

CCT REF	DESCRIPTION					MFR.	PART NO.
C1	100n	10%	630V	GREENCAP		ELNA	TYPE NH
C2	390p	BUTTON MICA				ERIE	654-017
C3	0.8-3p	TRIM				PH	2222-801-96003
C4	10p	10%	630V	NPO	CDS		
C5	1.2-10p	TRIM				STET	310601240
C6	3p3	10%	630V	NPO	CDS		
C7	1.2-10p	TRIM				STET	310601240
C8	15p	5%	630V	NPO	CDS		
C9	1.2-10p	TRIM				STET	310601240
C10	15p	5%	630V	NPO	CDS		
C11	4p7	10%	630V	NPO	CDS		
C12	1.2-10p	TRIM				STET	310601240
C13	1.2-10p	TRIM				STET	310601240
C14	1.2-10p	TRIM				STET	310601240
C15	0.8- 5p	TRIM				PH	2222-801-96003
C16	6p8	10%	630V	NPO	CDS		
C17	1p +/-	0.25p	630V	NPO	CDS		
C18	6p8	10%	630V	NPO	CDS		
C51	100n	10%	630V	GREENCAP		ELNA	TYPE NH
C52	390p	BUTTON MICA				ERIE	654-017
C53	0.8-3p	TRIM				PH	2222-801-96003
C54	10p	10%	630V	NPO	CDS		
C55	1.2-10p	TRIM				STET	310601240
C56	3p3	10%	630V	NPO	CDS		
C57	1.2-10p	TRIM				STET	310601240
C58	15p	5%	630V	NPO	CDS		
C59	1.2-10p	TRIM				STET	310601240
C60	15p	5%	630V	NPO	CDS		
C61	4p7	10%	630V	NPO	CDS		
C62	1.2-10p	TRIM				STET	310601240
C63	1.2-10p	TRIM				STET	310601240
C64	1.2-10p	TRIM				STET	310601240
C65	0.8-3p	TRIM				PH	2222-801-96003

CCT REF	DESCRIPTION					MFR.	PART NO.
C66	6p8	10%	630V	NPO	CDS		
C67	1p	+/- 0.25p	630V	NPO	CDS		
C68	6p8	10%	630V	NPO	CDS		
C101	10n	10%	630V	GREENCAP		ELNA	TYPE NH
C102	47u		25V	ELECTRO		ELNA	RB
C103	47u		25V	ELECTRO		ELNA	RB
C104	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C105	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C106	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C107	5-65p	FILM	TRIM			PH	2222-808-32659
C108	100n	10%	63V			SIEM	B83449-C6104-S2
C109A	22p	5%	630V	NPO	CDS		
C109B	5-65p	FILM	TRIM			PH	2222-808-32659
C110	22p	5%	630V	N750	CDS		
C111	82p	5%	630V	N750	CDS		
C131	10n	10%	100V	GREENCAP		SON	TYPE N
C132	100n	10%	100V	GREENCAP		SON	TYPE N
C133	10n	10%	100V	GREENCAP		SON	TYPE N
C134	100n	10%	100V	GREENCAP		SON	TYPE N
C151	10n	10%	630V	GREENCAP		ELNA	TYPE NH
C152	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C153	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C154	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C155	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C156	5-65p	FILM	TRIM			PH	2222-808-32659
C157A	22p	5%	630V	NPO	CDS		
C157B	5-65p	FILM	TRIM			PH	2222-808-32659
C158	82p	5%	630V	N750	CDS		
C201	100u		25V	ELECTRO		ELNA	RB
C202	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C203	47p	5%	630V	N750	CDS		
C204	47p	5%	630V	N750	CDS		
C205	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C206	1nF	10%	100V	GREENCAP		ELNA	TYPE N
C301	18p	5%	630V	N750	CDS		
C302	6p8	10%	630V	NPO	CDS		
C303	100n	10%	400V		MKT	SIEM	
C304	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C305	330p	20%	630V	YE	CDS		
C306	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C307	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C308	10u		16V		TANT		TAG
C309	680p	20%	630V	YE	CDS		
C310	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C311	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C312	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C313	220p	20%	630V	YE	CDS		
C314	1u	50V	ELECTRO		RBLL	ELNA	
C315	22p	5%	630V	N750	CDS		
C316	6p8	10%	630V	NPO	CDS		
C317	2-10p	FILM	TRIMMER			PH	2222-808-11109
C318	220n		50V	ELECTRO		ELNA	RBLL

CCT REF	DESCRIPTION				MFR.	PART NO.
C319	10p	5%	630V	NPO CDS		
C320	100n		63V	SIBABIT	SIEM	B37449-C6104-S2
C321	82p	5%	630V	N750 CDS		
C322	82p	5%	630V	N750 CDS		
C323	22u		100V	ELECTRO	PH	RB
C324	100n		63V	SIBABIT	SIEM	B37449-C6104-S2
C325	10p	10%	630V	NPO CDS		
C371	33p	10%	630V	N750 CDS		
C372	100n		63V	SIBABIT	SIEM	B37449-C6104-S2
C373	100p		630V	N750 CDS		
C374	470p	20%	630V	YE CDS		
C375	2n2	10%	100V	GREENCAP	ELNA	TYPE N
C376	47n	10%	100V	GREENCAP	ELNA	TYPE N
C377A	2-22p	FILM TRIMMER			PH	2222-808-11229
C377B	1u]	1%	100V	MKT	SIEM	SELECTED
C377C	10n]	PAIR	400V	MKT	SIEM	SELECTED
C377D	75p	5%	250V	POLYSTYRENE		
C377E	2-22p	FILM TRIMMER			PH	2222-808-11229
C401	2500u		25V	ELECTRO	ELNA	RT
C402	2500u		25V	ELECTRO	ELNA	RT
C403	47u		25V	ELECTRO	ELNA	RB
C404	47u		25V	ELECTRO	ELNA	RB
C405	100n		63V	SIBABIT	SIEM	B37449-C6104-S2
C421	1000u		35V	ELECTRO RB	ELNA	
C422	100u		25V	ELECTRO RB	ELNA	
C423	22u		100V	ELECTRO RB	PH	
C424	100n	10%	100V	GREENCAP	ELNA	TYPE N
C425	100n	10%	100V	GREENCAP	ELNA	TYPE N
C426	1n		2kV	CDS	ERIE	
C427	10n		3kV	CDS	ERIE	
C428	10n		3kV	CDS	ERIE	
C429	6n8		5kV	CDS	ERIE	
C430	6n8		5kV	CDS	ERIE	
C431	20n		2kV	CDS	ERIE	
C432	20n		2kV	CDS	ERIE	
C433	100n	10%	100V	GREENCAP	ELNA	TYPE N
C434	1n	20%	2kV	CDS	ERIE	
C435	10n	20%	3kV	CDS	ERIE	
C436	100n	10%	100V	GREENCAP	ELNA	TYPE N
C437	100n	10%	100V	GREENCAP	ELNA	TYPE N
C438	2cm TWISTED WIRE TRIMMER					
C439	1n	20%	630V	YE CDS		

POTENTIOMETERS

CCT REF	DESCRIPTION		MFR.	PART NO.
RV101	500R	CERMET PRESET	NOBLE	VTP
RV102	5k	LINEAR SWITCH POT	ALPS	4 GME 8031
RV103	50R	CERMET PRESET	NOBLE	VTP
RV104	10k	LINEAR CARBON POT	RADIOHM	P20 CE M7 10KA
RV105	2k	CERMET PRESET	NOBLE	VTP
RV106	200R	CERMET PRESET	NOBLE	VTP
RV107	100k	CERMET PRESET	NOBLE	VTP
RV108	1k	CERMET PRESET	NOBLE	VTP
RV109				
RV110				

CCT REF	DESCRIPTION		MFR.	PART NO.
RV131	5k	CERMET PRESET	NOBLE	VTP
RV132	200k	CERMET PRESET	NOBLE	VTP
RV151	500R	CERMET PRESET	NOBLE	VTP
RV152	5k	LINEAR SWITCH POT	ALPS	4 GME 8031
RV153	50R	CERMET PRESET	NOBLE	VTP
RV154	10k	LINEAR CARBON POT	RADIOHM	P20 CE M7 10KA
RV155	2k	CERMET PRESET	NOBLE	VTP
RV156	200R	CERMET PRESET	NOBLE	VTP
RV157	100k	CERMET PRESET	NOBLE	VTP
RV158	2k	CERMET PRESET	NOBLE	VTP
RV159	5k	CERMET PRESET	NOBLE	VTP
RV160	1k	CERMET PRESET	NOBLE	VTP
RV201	5k	CERMET PRESET	NOBLE	VTP
RV301	500k	LINEAR SWITCH POT DPDT	NOBLE	VTP
RV302	5k	CERMET PRESET	NOBLE	VTP
RV303	10k	CERMET PRESET	NOBLE	VTP
RV304	10k	LINEAR SWITCH POT	ALPS	VH13P-5M3121 10KB
RV305	200R	CERMET PRESET	NOBLE	VTP
RV306	1k	CERMET PRESET	NOBLE	VTP
RV307	200R	CERMET PRESET	NOBLE	VTP
RV371	20k	CERMET PRESET	NOBLE	VTP
RV372	1k	CERMET PRESET	NOBLE	VTP
RV373	5k	LINEAR SWITCH POT	ALPS	4 GME 8031
RV374	500k	CERMET PRESET	NOBLE	VTP
RV375				
RV421	200k	CERMET PRESET	NOBLE	VTP
RV422	200k	CERMET PRESET	NOBLE	VTP
RV423	3M	LINEAR CARBON POT	NOBLE	VCU
RV424	10k	LINEAR SWITCH POT	RADIOHM	DPST ROTARY
RV425				

SEMI CONDUCTORS

U101	NPD	8303 DUAL FET	NS	
U102	NS733	AMPLIFIER	NS	
U103	CA3086	TRANSISTOR ARRAY	NS or F	
U151	NPD	8303 DUAL FET	NS	
U152	NS733	AMPLIFIER	NS	
U153	CA3086	TRANSISTOR ARRAY	NS or F	
U201	LF 351 or LF 356 FET OP AMPLIFIER		NS	
U202	CD4001B	CMOS		
U203	CD4013B	CMOS		

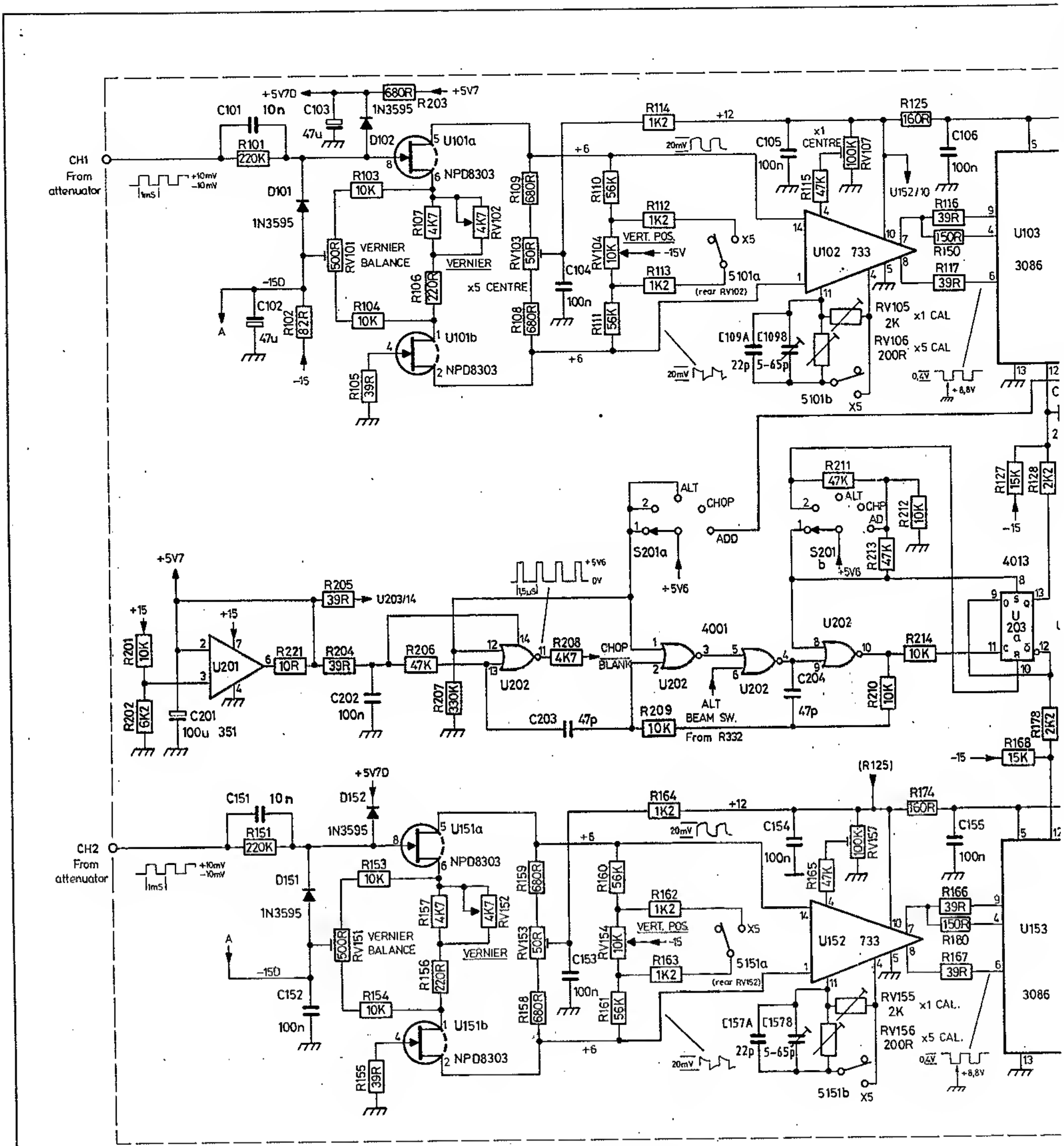
CCT REF	DESCRIPTION		MFR.	PART NO.
U301	LF 353	DUAL OP-AMP	NS	
U302	CA3086	TRANSISTOR ARRAY	RCA or NS	
U303	MC10109	ECL GATES	MOT	
U304	74CH02	CMOS GATES		
U305	LF 356	FET OP AMPLIFIER	NS	
U371	LF353	DUAL OP-AMP	NS	
U401	uA7815	+15V REG	F or NS	
U402	uA7915	-15V REG	F or NS	
Q101	PN4249	PNP TRANSISTOR		
Q131	PN4249	PNP TRANSISTOR		
Q132	PN4249	PNP TRANSISTOR		
Q133	MPS6544	NPN TRANSISTOR		
Q134	PN4249	PNP TRANSISTOR		
Q135	MPS6544	NPN TRANSISTOR		
Q136	PN4249	PNP TRANSISTOR		
Q201	PN4249	PNP TRANSISTOR		
Q301	PN4258	PNP TRANSISTOR		
Q302	BC547	NPN TRANSISTOR		
Q303				
Q304	PN4249	PNP TRANSISTOR		
Q305	PN4249	PNP TRANSISTOR		
Q306	BC547	NPN TRANSISTOR		
Q307	BF469	NPN TRANSISTOR		
Q308	BF469	NPN TRANSISTOR		
Q309	PN4249	PNP TRANSISTOR		
Q310	BF469	NPN TRANSISTOR		
Q311	BF469	NPN TRANSISTOR		
Q371	PN4121	PNP TRANSISTOR		
Q372	PN3642	NPN TRANSISTOR		
Q421	2N 3055	NPN TRANSISTOR] MATCHED		
Q422	2N 3055	NPN TRANSISTOR] PAIR		
Q423	2N 5550	NPN TRANSISTOR		
Q424	PN3645	PNP TRANSISTOR		
Q425	PN3645	PNP TRANSISTOR		
Q426	MPS6544	NPN TRANSISTOR		
Q427	BC547	NPN TRANSISTOR		
D101	IN3595	DIODE		
D102	IN3595	DIODE		
D103				

CCT REF	DESCRIPTION	MFR.	PART NO.
D131	BZX79/C11V ZENER DIODE	PH	
D132	BZX79/C11V ZENER DIODE	PH	
D151	IN3595 DIODE		
D152	IN3595 DIODE		
D153			
D301	IN4148 DIODE		
D302	IN4148 DIODE		
D303	IN4148 DIODE		
D304	IN4148 DIODE		
D305	IN4148 DIODE		
D306	IN4148 DIODE		
D307	IN4148 DIODE		
D308	IN4148 DIODE		
D309	IN4148 DIODE		
D310	IN4148 DIODE		
D372	BZX79/C16V ZENER DIODE	PH	
D373	IN4148 DIODE		
D401	IN4004 DIODE		
D402	IN4004 DIODE		
D403	IN4004 DIODE		
D404	IN4004 DIODE		
D405	IN4004 DIODE		
D406	IN4004 DIODE		
D407	IN4004 DIODE		
D408	GREEN LED	FAIR	FLV 340
D421	IN4004 DIODE		
D422	BY406 DIODE	PH	
D423	BY406 DIODE	PH	
D424	BY409 DIODE	PH	
D425	BY409 DIODE	PH	
D426	BY409 DIODE	PH	
D427	BY409 DIODE	PH	
D428	IN4148 DIODE		
D429	IN4148 DIODE		
D430	IN4148 DIODE		
D431	IN4148 DIODE		
D432	IN4148 DIODE		
S1	3 POS SLIDE SWITCH	NSF	SM2-3
S2	3 DECK ROTARY SWITCH (PXM)	AB	100-129
S51	3 POS SLIDE SWITCH	NSF	SM2-3
S52	3 DECK ROTARY SWITCH (PXM)	AB	100-129

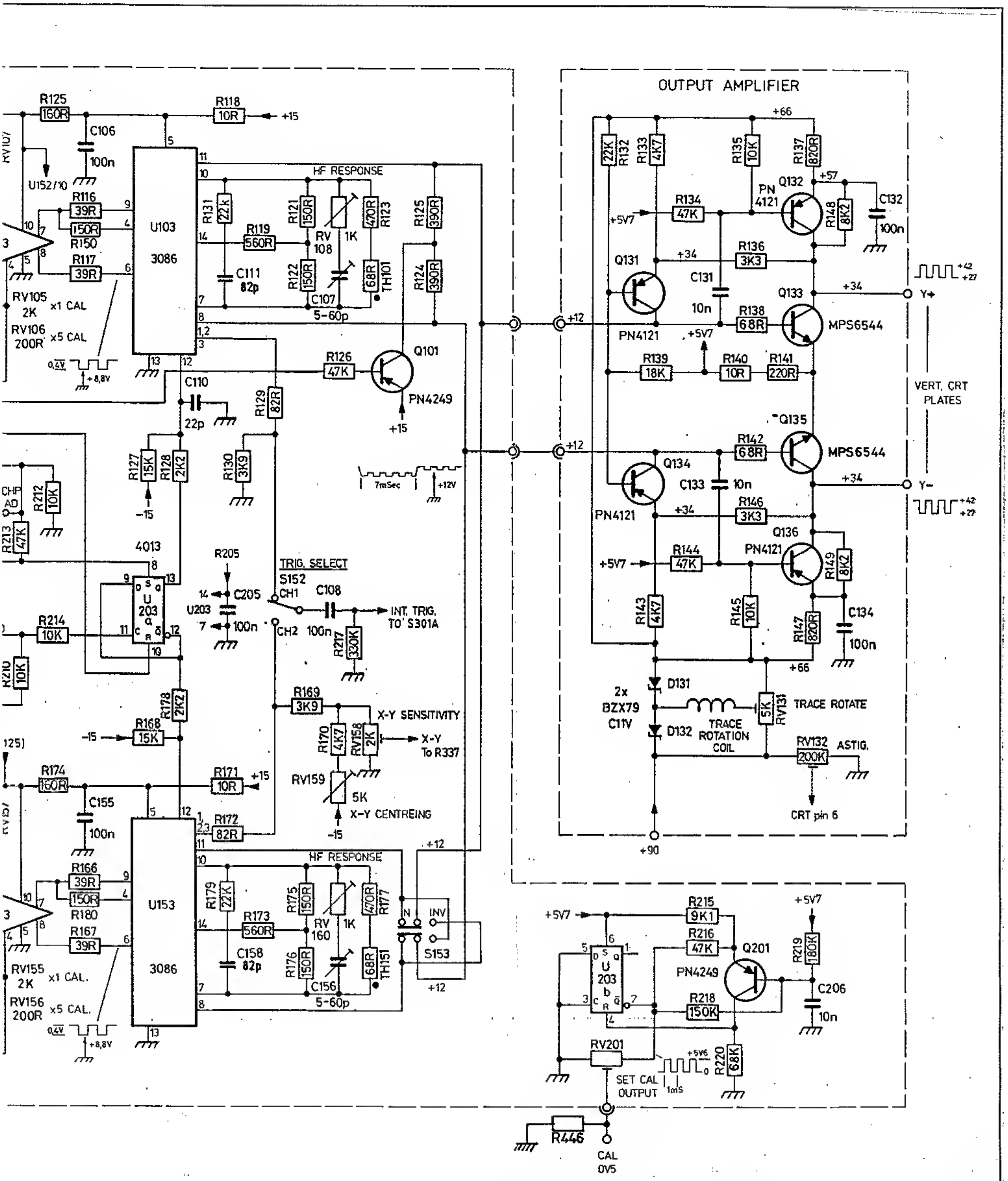
BWD B21 Parts List

CCT REF	DESCRIPTION	MFR.	PART NO.
S101	A & B ON REAR OF RV102		
S151	A & B ON REAR OF RV152		
S152	A & B A-C 3 SECTION ISOTAT	BWD	100-160
S201	2 POLE 5 POSITION ROTARY SWITCH	LORLIN	
S302	DPST PUSH PULL SWITCH ON REAR OF RV301		
S303	DPST PUSH PULL SWITCH ON REAR OF RV304		
S371	2 DECK ROTARY SWITCH	BWD	100-150
S372	DPDT PUSH PULL SWITCH ON REAR OF RV373		
S401	DPST ROTARY SWITCH ON REAR OF RV424		
BRC	BEAM ROTATION COIL	BWD	090-217
T401	POWER TRANSFORMER	BWD	090-216
T421	CONVERTER TRANSFORMER	BWD	090-215
	CRT	MAT	140 CGB31
	CRT SOCKET	HOSIDEN	HPS 0051-01-010
	CRT SHIELD	BWD	1742A
TH101	68R THERMISTOR	PH	2322-610-11689
TH151	68R THERMISTOR	PH	2322-610-11689
	POWER CORD GREEN	PEASTON	1555A
	POWER CORD GRIP	UTILUX	H2097
F401	FUSE HOLDER	INTEL-ECSA	PF-7

CCT REF	DESCRIPTION	MFR.	PART NO.
F501	FUSE LINK 160MA DELAY 250V		5 x 20mm
F502	FUSE LINK 160MA DELAY 250V		5 x 20mm
	BNC SOCKETS		UG1094U
	4MM SOCKETS	MULTI-CON	EB4
	GRATICULE, LIGHT BLUE	MULFDRD	No. 310K
	ESCUTCHEON MOULDING	BWD	510A
	PUSH BUTTON KNOBS	BWD	K10W
	ATTENUATOR KNOB	BWD	K23W
	TIME BASE KNOB	BWD	K23W
	CHANNEL SELECTOR KNOB	BWD	K20W
	VERTICAL POSITION KNOB	BWD	K20W
	HOR. POSITION KNOB	BWD	K20W
	INTENSITY KNOB	BWD	K21W
	FOCUS KNOB	BWD	K21W
	TRIG LEVEL KNOB	BWD	K20W
	VERNIER KNOB	BWD	K20W



All waveforms measured with 0,5V 1KHz square wave input. Attenuators set to 0.1V/div. T/base to 0,5mS/div. and all verniers to CAL.



ISS	C/N	DATE
01		26-8-82
02		18-7-83
03		7-11-83
04	83/86	17/4/86

SCALE :

TOL. ±0,2mm unless specified.

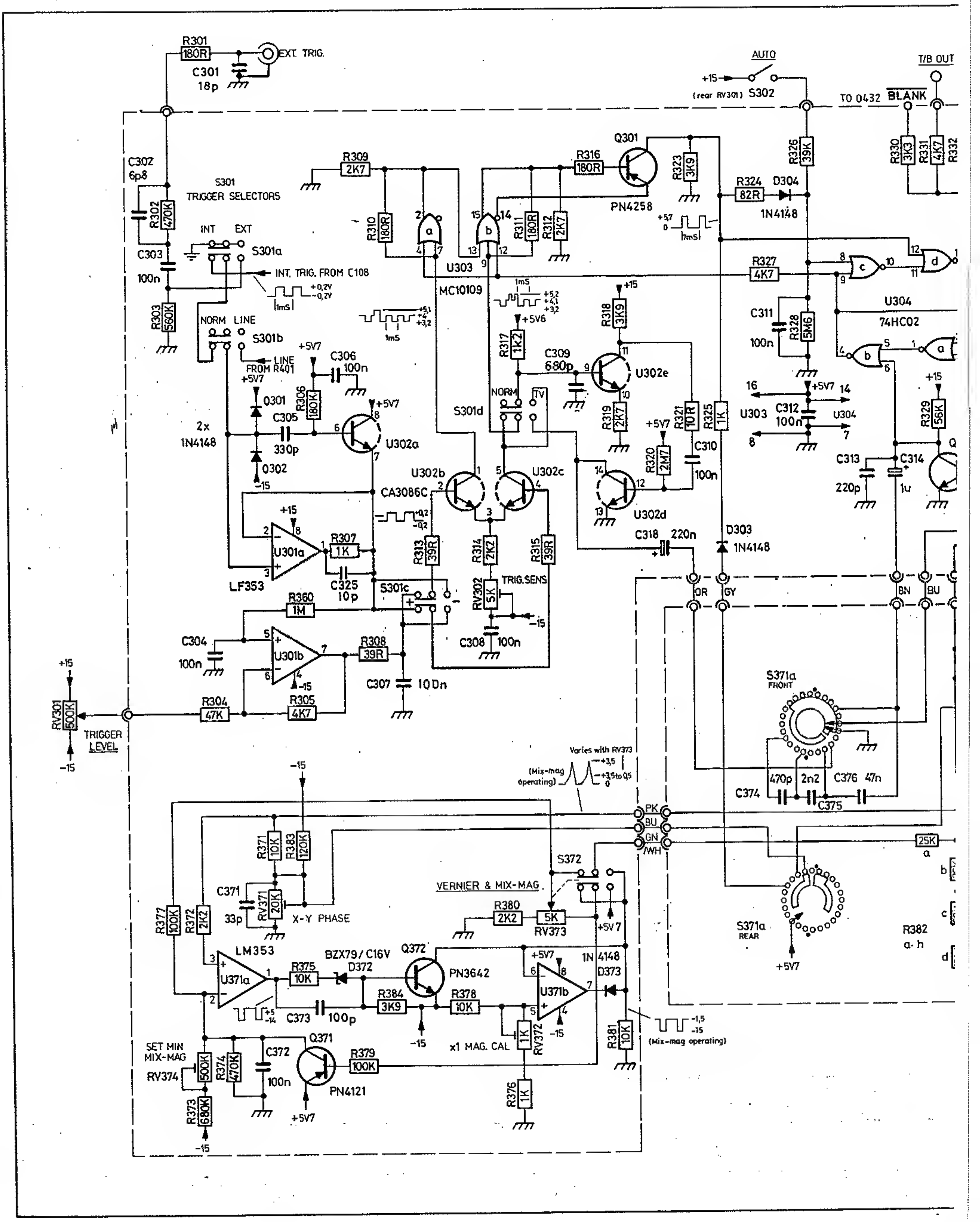
BWD INSTRUMENTS PTY. LTD. MELBOURNE AUSTRALIA

TITLE: CIRCUIT DIAGRAM AMPLIFIERS 821 OSCILLOSCOPE

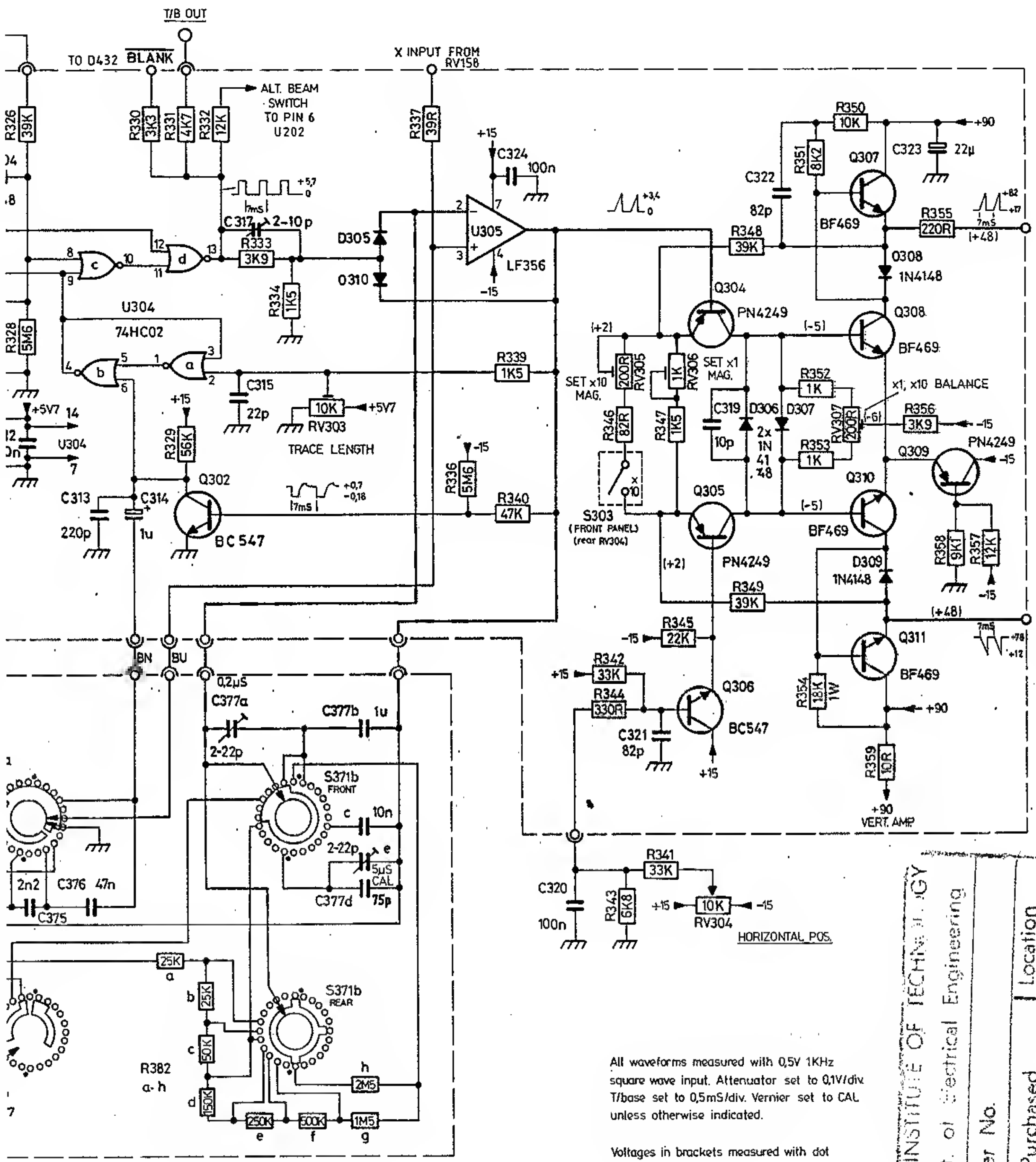
DRAWN | CHECKED | APP'D

DRG. No: 1897

SHT. OF



R301 180R
EXT. TRIG.
C301 18p
C302 6p8
R302 470K
S301 TRIGGER SELECTORS
INT EXT
S301a
C303 100n
INT. TRIG. FROM C108
R303 560K
NORM LINE
S301b
LINE FROM R401
+5V7
D301
D302
2x 1N4148
C305 330p
R306 180K
C306 100n
U302a
U301a
LF353
R307 1K
C325 10p
R360 1M
C304 100n
U301b
R308 39R
C307 100n
R304 47K
R305 4K7
RV301 500K
TRIGGER LEVEL
R309 2K7
R310 180R
U303
MC10109
R316 180R
Q301
PN4258
R323 3K9
R311 180R
R312 2K7
S301d
NORM TV
U302b
U302c
CA3086C
R313 39R
R314 2K2
R315 39R
S301c
RV302 5K
TRIG.SENS.
C308 100n
R317 1K2
+5V6
C309 680p
R318 3K9
U302e
R319 2K7
R320 2M7
R321 10R
C310 100n
U302d
C318 220n
AUTO
S302
(rear RV301)
T/B OUT
TO 0432 BLANK
R326 39K
R330 3K3
R331 4K7
R332
R324 82R
D304 1N4148
R327 4K7
U304 74HC02
C311 100n
R328 5M6
R325 1K
C312 100n
D303 1N4148
R329 56K
C313 220p
C314 1u
OR GY BN BU
S371a FRONT
C374 470p
2n2
C375
C376 47n
-15
R371 10K
R383 120K
C371 33p
RV371 20K
X-Y PHASE
Varies with RV373
(Mix-mag operating)
PK BU GN WH
S372
VERNIER & MIX-MAG
R380 2K2
RV373 5K
R377 100K
R372 2K2
LM353
U371a
R375 10K
BZX79/C16V D372
Q372 PN3642
R384 3K9
R378 10K
U371b
1N4148 D373
C373 100p
x1 MAG. CAL
RV372 1K
R381 10K
(Mix-mag operating)
SET MIN MIX-MAG
RV374 500K
R374 470K
C372 100n
Q371 PN4121
R379 100K
R373 680K
R376 1K
25K
S371a REAR
R382 a-h



All waveforms measured with 0,5V 1KHz square wave input. Attenuator set to 0,1V/div. T/base set to 0,5mS/div. Vernier set to CAL unless otherwise indicated.

Voltages in brackets measured with dot centred on X-Y.

ISS	C/N	DATE
01		23.3.82
02		20.4.83
03	47/84	1.5.84
04	83/86	17/4/86

SCALE :

TOL. ±0,2mm unless specified.

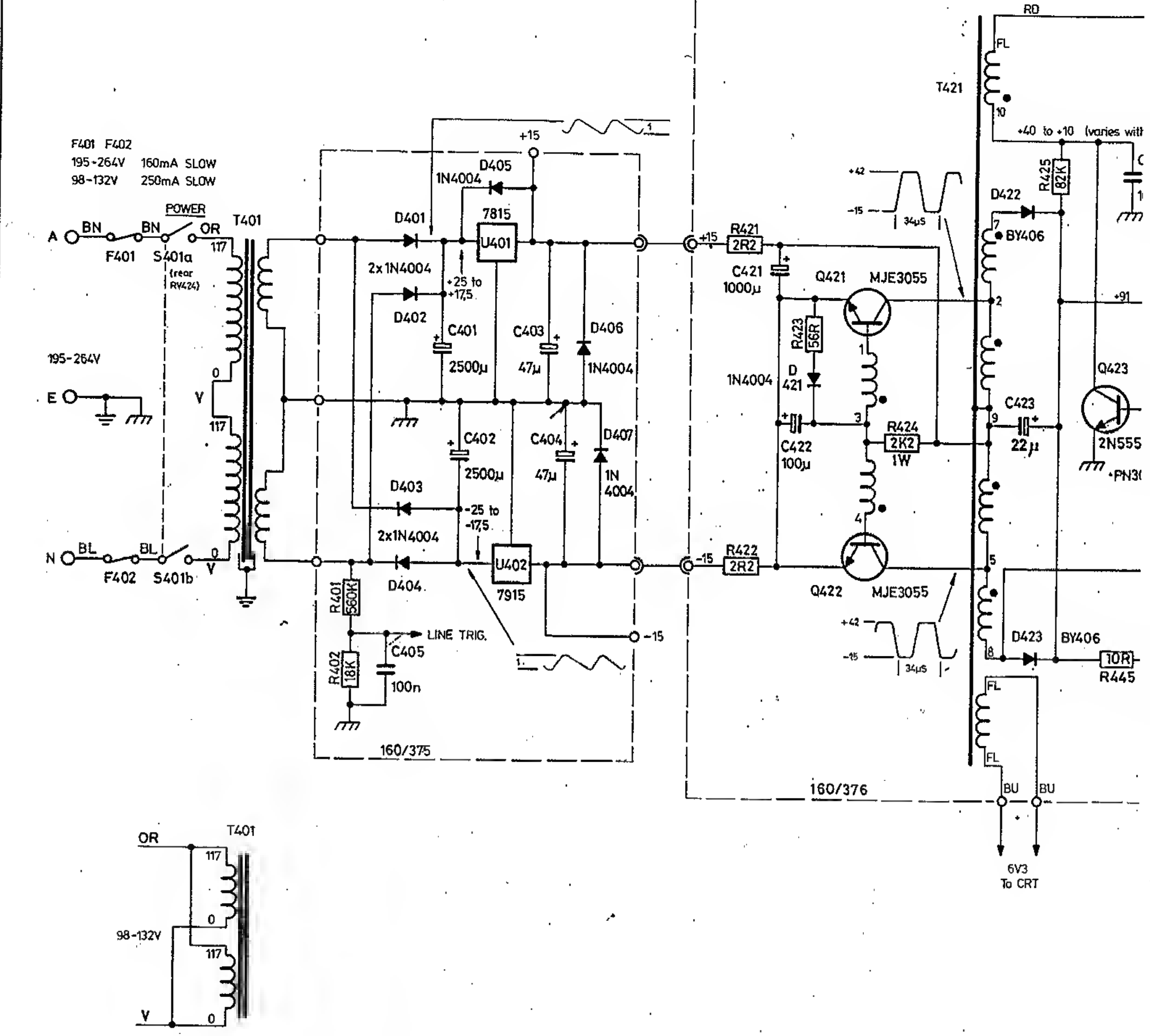
BWD INSTRUMENTS PTY. LTD. MELBOURNE AUSTRALIA

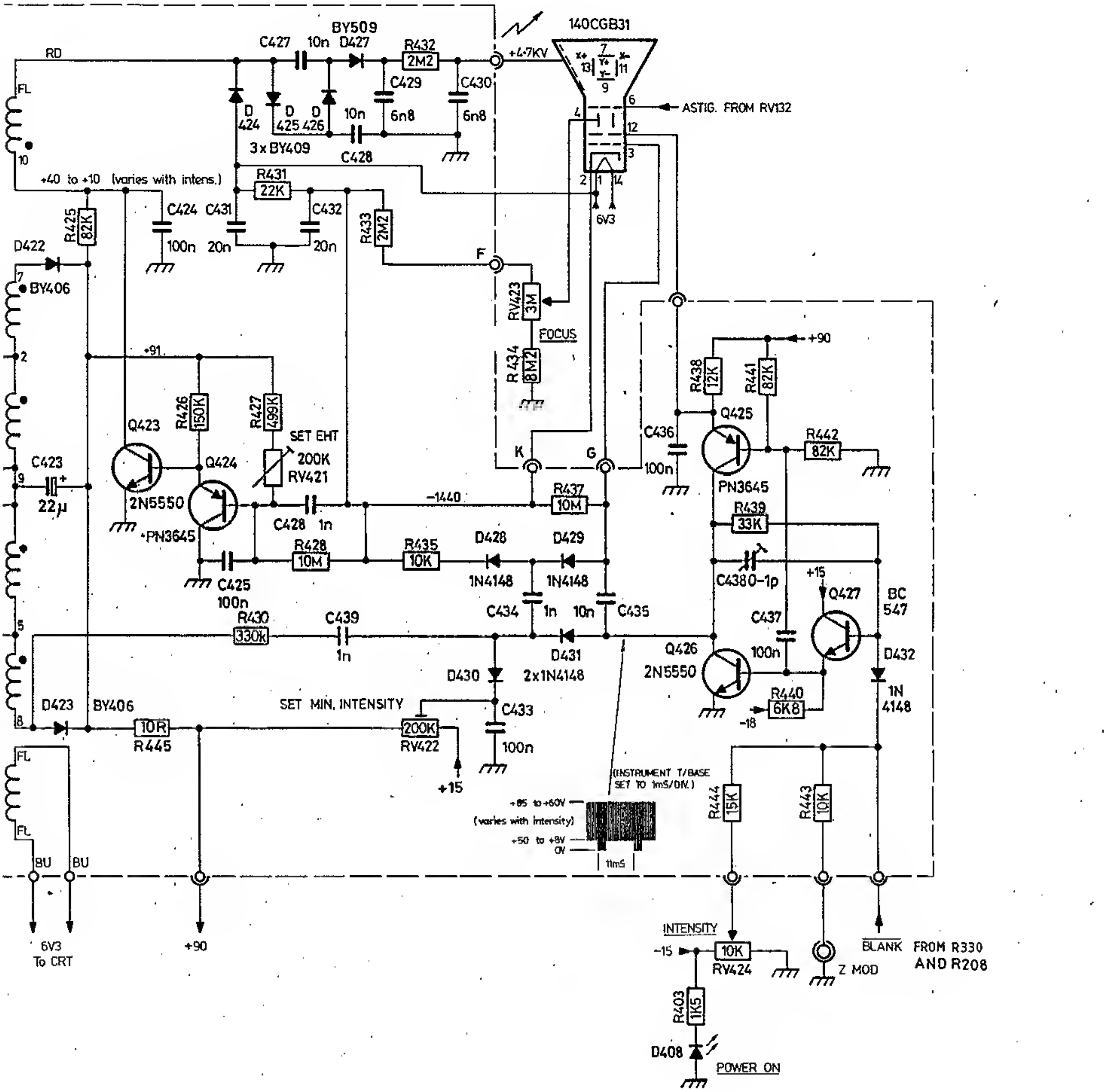
TITLE: CIRCUIT DIAGRAM T/BASE & HORIZ. AMP. 821 OSCILLOSCOPE

DRAWN | CHECKED | APP'D

DRG. No: 1898

SHT. OF


F401 F402
195-264V 160mA SLOW
98-132V 250mA SLOW
POWER
A
BN
BN
OR
F401
S401a
(rear RV424)
T401
117
0
117
0
V
195-264V
E
N
BL
BL
F402
S401b
D401
D402
2x1N4004
D403
D404
2x1N4004
+25 to +17,5
-25 to -17,5
C401
2500µ
C402
2500µ
1N4004
D405
7815
U401
U402
7915
+15
-15
C403
47µ
C404
47µ
D406
1N4004
D407
1N 4004
R401
560K
R402
18K
C405
100n
LINE TRIG.
160/375
+15
R421
2R2
C421
1000µ
Q421
MJE3055
R423
56R
D 421
1N4004
C422
100µ
R424
2K2
1W
-15
R422
2R2
Q422
MJE3055
+42
-15
34µS
T421
RD
FL
+40 to +10 (varies with
R425
82K
D422
BY406
+91
Q423
2N555
C423
22µ
+PN3
D423
BY406
10R
R445
FL
FL
BU
BU
6V3
To CRT
160/376
OR
T401
117
0
98-132V
117
V
0



ISS	C/N	DATE
a		18.8.82
02		20.4.83
03		18.7.83
04	40/84	10.4.84
5	97/86	28/4/86

SCALE :

TOL. ±0,2mm unless specified.

BWD INSTRUMENTS. PTY. LTD. MELBOURNE AUSTRALIA.

TITLE: CIRCUIT DIAGRAM POWER SUPPLY 821 OSCILLOSCOPE

DRAWN | CHECKED | APP'D

DRG. No: 1899

SHT. OF

BWD INSTRUMENTS PTY. LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 821

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
53720	1	19.1.84			
	4				

Issue	Sect.	Page	Cct.	AMENDMENT
1	8	4	1899	R427 was 499K now 560K ¼W 5% M.F.
1	8	6	1897	C206 InF 100V 10% GREENCAP added.
2	8	7	1899	C438 was 0.68pF, now twisted wire trimmer
3	8	5	1897	R446 820R 5% ¼W MF added.
4	8	6	1897	C109A was 82pF, now 22 pF NPO.
4	8	6	"	C109B added, 5-65pF Trimmer, PH 2222,808,32659
	8	6	"	C157A was 82pF now 22 pF NPO
	8	6	"	C157B added, 5-65pF Trimmer, PH 2222,808,32659
	8	6	"	C158, N750 temp. co-efficient added
	8	6	1898	C323 was 10uF, now 22uF 100V RB.
	8	6	1899	C423 was 10uF now 22uF 100V RB.
	8	7	1898	C377D was 82p now 75p